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FIGURES 1-5

KASSAS and ZAHRAN, *Bulletin de la Société de Géographie d'Égypte*, t. XXXVIII, p. 155-194.

Errata : The photographs, not the legends, of plates I and II should be exchanged.

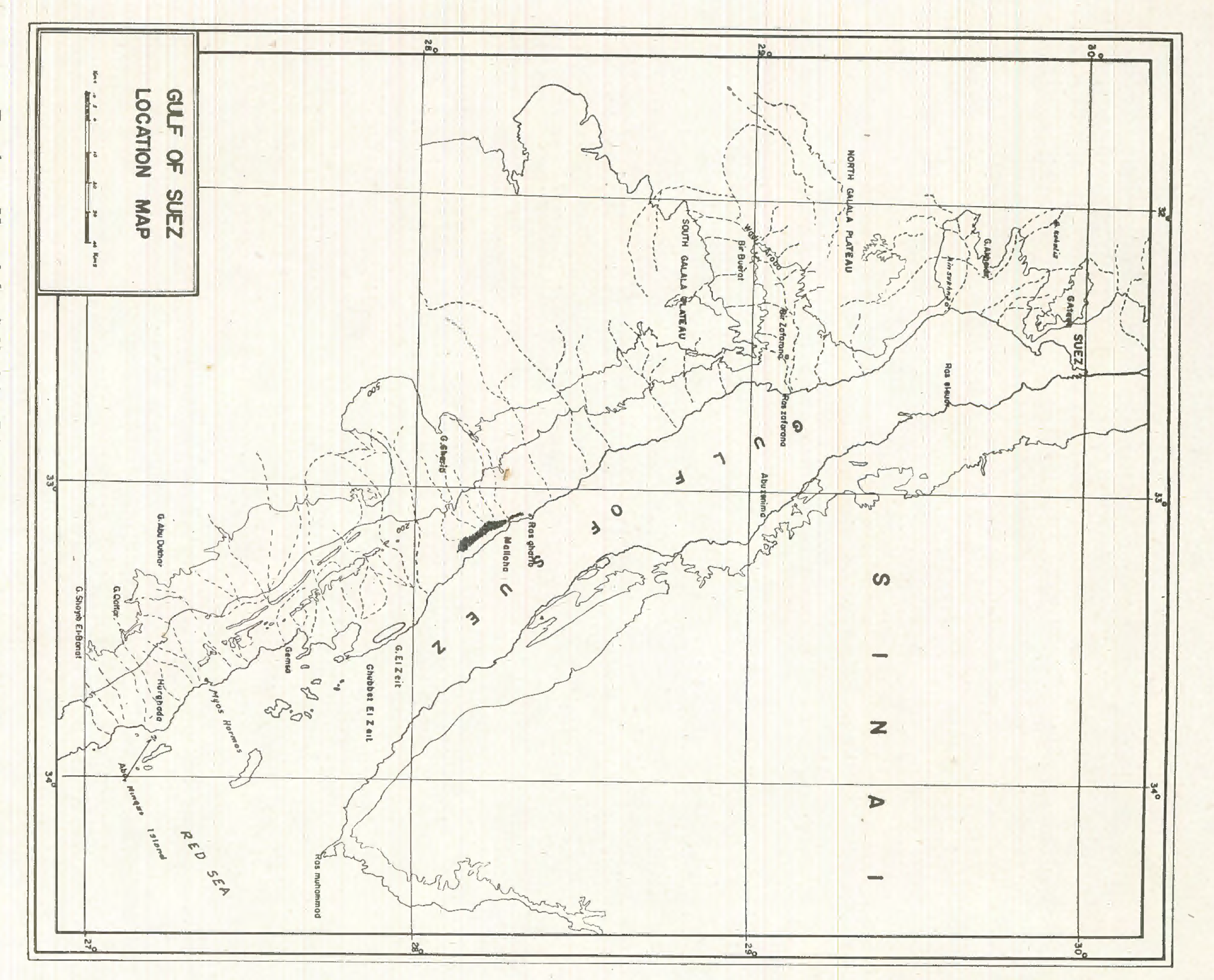


Fig. 1. — Map of the Gulf of Suez showing the area surveyed in this paper (Part II) and the previous paper (Part I).

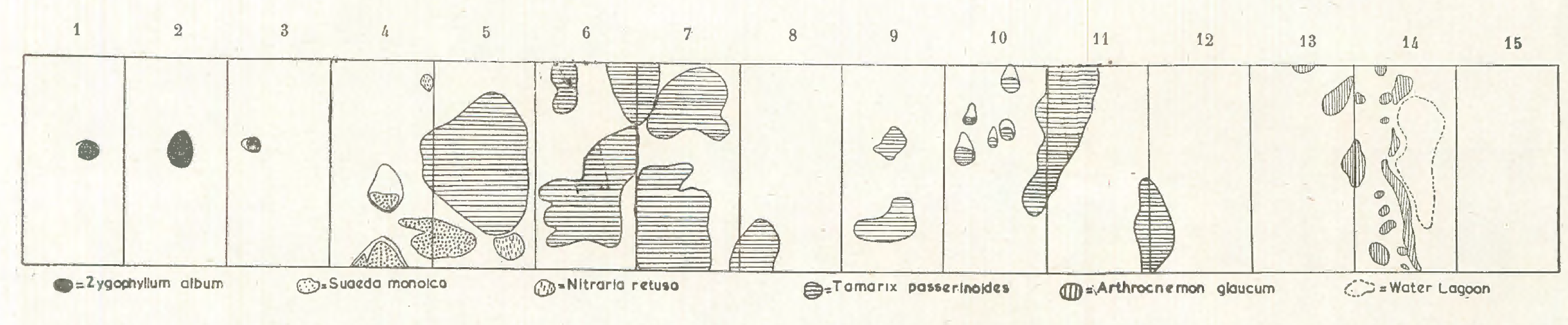


Fig. 2. — Chart quadrats of transect set to represent the vegetation of the *Mellaha* area, see text. Quadrats 1-3 (left hand end) show the *Zygophyllum album* open growth; quadrat 4 shows the mixed growth of *Suaeda monoica* and *Nitraria retusa*; quadrats 5-12 show the hillocks of *Tamarix passerinoides*; quadrats 13-14 show the *Arthrocnemon glaucum* growth fringing the lagoon.

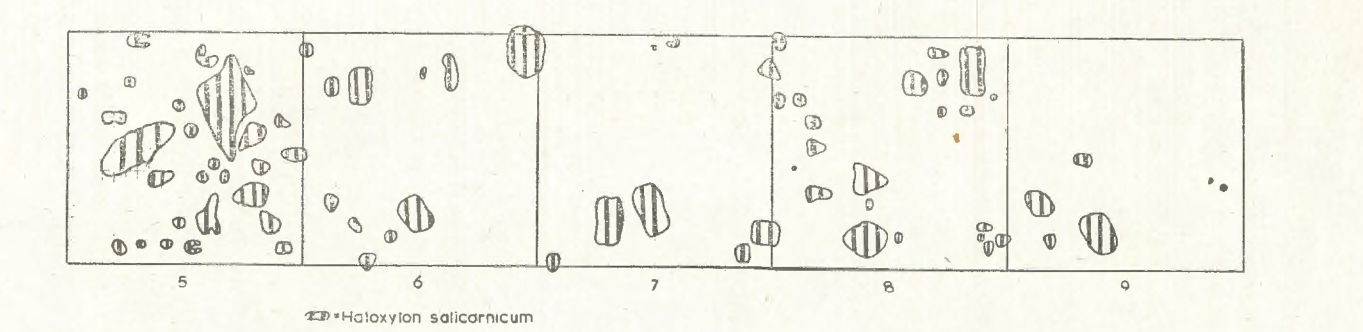


Fig. 3. — Charts of quadrats representing the belt transect set across the main channel of wadi Dib showing the pure growth of *Haloxylon salicornicum*.

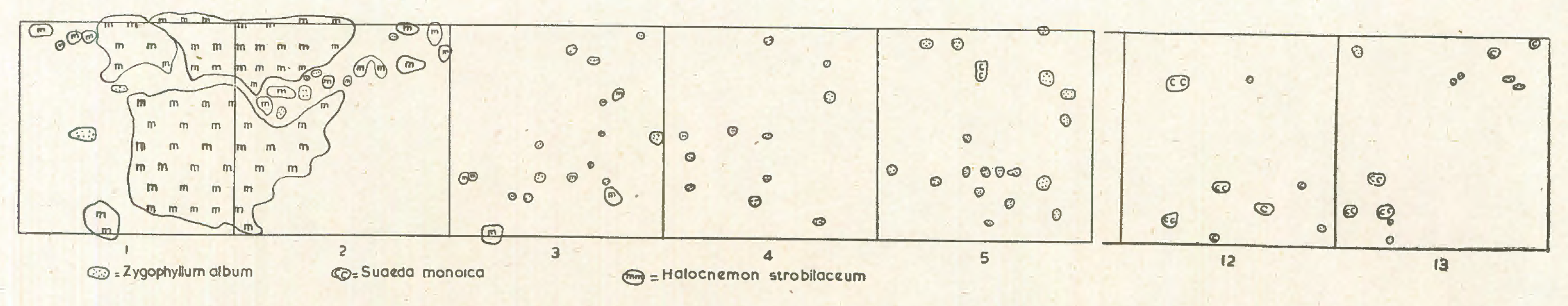


Fig. 4. — Charts of quadrats 1-5 representing the seaward of the belt transect set across the Ghubbet-el-Zeit coast. Quadrats 1 and 2 show the massive growth of *Halocnemon strobilaceum* on the littoral sand bars, quadrats 3-5 represent the zone of *Zygophyllum album*, quadrats 12-13 represent the *Suaeda monoica* zone.

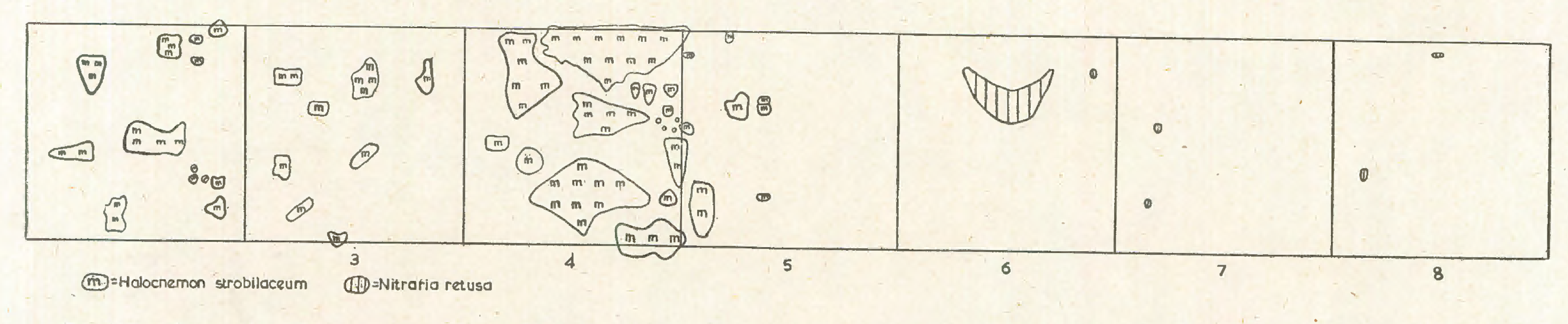


Fig. 5. — Charts of quadrats representing a part of the belt transect set across the coast of *Myos Hormos*. Quadrats 2-5 represent the zone of *Halocnemon strobilaceum*, quadrats 6-8 represent the zone of *Nitraria retusa*.

LE CAIRE
IMPRIMERIE DE L'INSTITUT FRANÇAIS D'ARCHÉOLOGIE ORIENTALE
1966

SEDENTARISATION OF NOMADS
IN THE
BUTANA REGION OF NORTHERN SUDAN

BY

MOHAMED AWAD [1]

I. — INTRODUCTION.

The present report concerns the Butana Region of the Sudan, particularly with regard to the tribes of the area, and the possibility of advising on the measures to be taken for carrying out a programme of sedentarisation of the nomads of the Butana, or at least of those tribes who have been affected by the Khashm-el-Qirba Project.

In order to grasp the nature of the present mission, it should be remembered that in October 1962, the I. L. O. Panel on Indigenous and Tribal Populations recommended that :

« The I. L. O. should explore, in close consultation with the other organisations concerned, ways and means of developing a programme of research and operational activities designed to assist requesting governments in the formulation and execution of national and regional projects for the improvement of conditions of life and work of their nomadic

[1] In connection with the Khashm-el-Qirba Project, which was mainly concerned with the settlement of immigrants from the Wadi Halfa area, the Sudan Government wished to settle some of the Butana Nomadic Groups ; and asked the International Labour Organisation to study and suggest ways and means of carrying out this development. Dr. Awad was appointed by the I.L.O. to study the question and report to the Organisation, which he did in January 1964. The Sudan Authorities have authorised publication of his findings ; and the editor of this Journal finds it best to publish the report as it was written without substantial modifications.

and semi-nomadic tribal populations, and the integration of these populations into national life by means of settlement schemes or any other action which might prove necessary.»

Accordingly, the Government of Sudan asked the I. L. O. for assistance in developing the Khashm-el-Qirba Project for the benefit of the Butana tribes. During the International Labour Conference of 1963 the question was discussed with the Sudanese Minister of Labour during his stay in Geneva, and it was agreed, as a preliminary step, to send an expert for two months (between October 1963 and February 1964) whose duty would be :

« to study the situation on the spot, and advise on what further steps could be taken towards the implementation of the project, and the fields in which the I. L. O. could extend technical assistance.»

The Director-General of the International Labour Office accordingly designated Professor Mohamed Awad, a former Director of the Cairo Institute of Sudanese studies and a former Minister of Education in the United Arab Republic, for the purpose.

A further reference to the nature of the mission was contained in the Mission Order issued by the I. L. O. on 15 November 1963, which indicated that the object of the mission was « to assist the Government of the Sudan in drawing up a plan concerning the sedentarisation of the tribes in the Khashm-el-Qirba area (North Sudan)».

This description and the previous one, emphasised the importance of collaboration with the authorities in the Sudan, a collaboration which was always very close and extremely cordial and valuable, in all aspects of the present study. This study was commenced on 19 November 1963 and included the following activities :

1. Conferences in Khartoum with members of the Ministry of Local Government, including His Excellency the Minister, the Under-Secretary of State, the President of the Executive Council of Kassala Province, who is also the Deputy-Governor of that Province.

2. Detailed study of official documents and files kindly placed at the disposal of the expert by the officials of the Ministry of Local Government and relating to the condition of tribes and tribal-sections in the Sudan.

3. Studies on the spot of the Khashm-el-Qirba Project in all its aspects.

4. Visits to the principal tribes of the Butana region, and meetings and conferences with their chiefs and dignitaries.

5. Although living in Qirba most of the time, visits also covered the region of Gedaref and Kassala, being the head-quarters of the activities relating to the questions treated.

6. A visit was also effected to the country of the Hadendowa in the Gash-Delta, in order to study the effects of an experiment on sedentarisation of this famous tribe, immortalised in the poetry of Rudyard Kipling. A visit was also planned to the Jezira, to have an idea of the effect of the experiment on « social guidance», but shortage of time prohibited the carrying out of this visit.

It is clear from the foregoing statements that the present report is not concerned with the problem of nomadism in the whole of the Sudan, nor even with nomadism in the whole of the Butana region; but only with those nomadic or semi-nomadic groups affected by the Khashm-el-Qirba Project, and perhaps with some of their immediate neighbours. The problem of sedentarisation of all or nearly all nomads and semi-nomads of the Sudan has, of course, been seriously considered by the Sudan Government; and measures to deal with the problem in some way or other have been taken from time to time. But it is fully realised by the Sudanese authorities that nomadism in one region presents questions which are rather different from those encountered in another region; and this study is only concerned with the limited area of the Butana, and in particular that portion of the Butana which felt the impact of the Khashm-el-Qirba Project.

Sedentarisation of the nomads has already been effected in the Sudan, as a result of an elaborate irrigation project such as the Jezira and the Gash-Delta projects. But in both these cases, the main consideration was that of agricultural development. Sedentarisation of the nomads was only a side issue. But in the Butana region there is a new irrigation

project, and agricultural development project, which, however, is specifically intended to help to sedentarise the Butana tribes. It is well-known that in the Jezira, immigrant labour was employed in addition to the local inhabitants. But in the Butana project, the authorities wish to promote the settlement of the local inhabitants, thereby achieving more than one objective. In fact the Khashm-el-Qirba Project includes :

1. The construction of a dam and a reservoir.
2. Electric generation from the dam.
3. A canal to carry water for irrigation.
4. Bringing under cultivation 150,000 feddans in the initial stage, to be expanded to 500,000 feddans in later stages. (A feddan is roughly equal to one acre).
5. Settlement of about 50,000 of the Halfa people, whose lands will be inundated by the Aswan High Dam.
6. Building a sugar factory.
7. Settling the local nomads.

All these objectives are being carefully and assiduously pursued; and although the question of settling the nomads will, by its very nature, be the last to be accomplished, it is by no means the least important.

In the following pages a brief analysis of all points, as well as other questions, will be attempted, as this is essential for a full grasp of the main question.

II. — THE BUTANA.

The Butana is an area of the Sudan lying between the 18th and the 12th degrees of North Latitude and between 33° and 36° of E. Longitude. Its area should be some 120,000 square kilometres, forming part of Kassala Province. Its situation is quite unique, being bounded to the North-West by the Main River Nile from the town of Atbara to Khartoum, to the west by the Blue Nile and its tributary : the Rahad, and to the east by the River Atbara, from the point where it emerges

from the highlands of Ethiopia to its junction with the Main Nile at the town of Atbara. Being mainly surrounded by water on most sides, the northern part of the Butana has been known to the ancients as the Island of Meroe, after the city of that name, whose ruins still exist in the neighbourhood of the town of Shendy.

The Butana consists of extensive plains, which look almost flat, with occasional hills of crystalline rocks, protruding from the ubiquitous fine clay covering, which are often given the dignified name of « Gebel» or mountain, although they never rise to any very considerable height. They certainly constitute interesting landmarks, and are further useful by enabling water to percolate to lower depths and become available for digging shallow wells. Otherwise the surface is generally very flat, with hardly any perceptible gradient. There is nevertheless a very slight slope from the east and south towards the west and north. Such a slope helps the River Atbara to pursue its course towards its junction with the Nile at Atbara town. But the River Atbara gathers its real momentum from its rapid drop from the Ethiopian highlands to the plains of the Butana.

The flat surface of the Butana creates ideal surface conditions for the agricultural engineer. The soil is of fine clay, whose fertility is fairly evident from its natural vegetation, and of which an early examination has given a fair promise. The excessive flatness, however, causes the summer rains to accumulate in the form of swampy tracts instead of running into valleys or depressions in which the water could be stored and controlled. In addition to the Khashm-el-Qirba Project, which relies on the Atbara flood, water storage is often effected by the digging of artificial depressions, known as *hafirs*. The Sudan authorities have exerted great efforts and expended large sums for the provision of such artificial ponds all over the Northern Sudan, including the land of the Butana. One of the most famous is at Qadanbaliah « lake» in the Southern Butana, which is fed by the summer and autumn rainfall, and contains water almost all the year round.

The climate of the Butana is much drier in the north than in the south. There are three distinct areas, the northern, the central and the southern, in which the rainfall ranges from about 200 mm. to 800 mm.

The following details illustrate this general picture :

Station	Lat./longitude	Height above sea-level	Annual rainfall in mm.
Abu Deleiq	15°.55 — 33°-59	400 metres	194
Kassala	15°.00 — 36°.5	507 »	331
K-el Qirba	14°.59 — 35°.57	480 »	400 (approx.)
Gadaref	14°.2 — 35°.30	500 »	618
Roseiris	11°.50 — 34°.01	466 »	761
Qallabat	12°.48 — 36°.10	762 »	898

Thus the area with which we are mainly concerned, namely the central Butana, has approximately 400 mm. of rain, which falls in the months of June to October with a clear maximum of 140-160 mm. in the month of August. Although the rainfall is not always regular, either in its quantity or season, it is nevertheless, quite clear that most of the Butana region is not a land for nomadic life, but may be considered as one into which nomads have automatically driven their flocks while wandering from place to place.

In addition to the rainfall, there are a great many shallow wells, especially near the isolated mountains, and deep wells are being dug, with an abundant water supply, in addition to the increasing number of « hafirs». Now with the Qirba project a fair amount of water supply is available, and the Butana is the ideal land for persuading its nomads and semi-nomads to pursue a more settled existence.

In addition to the climatic features described, we should note further that the Butana is surrounded by rivers, the main river Nile-Atbara to Khartoum, the Blue Nile with its tributaries the Rahad and Dinder, and the River Atbara which emerges from the Ethiopian highlands near the town of Qallabat and flows northwards to join the main river Nile at the town of Atbara. Both the Main River and the Blue Nile are centres of relatively large settlements with a fair density of population.

Because of these settlements, a considerable number of towns have grown, including the « triple capital» Khartoum-North Khartoum and

Omdurman, and the towns of Atbara, El Damer and Shendi. All these are on the main Nile. On the Blue Nile there are further great centres like Wad Madani, Sennar and Singa. All these centres are situated on the western flanks of the Butana. On the eastern side, however, settlements are few and far between, and consist mainly of small villages built by semi-nomads who often practise a kind of shifting agriculture. For long stretches the River Atbara flows, with Khashm-el-Qirba as the only settlement of any size on its steep banks. We may now turn to a consideration of the inhabitants of the Butana and their mode of life.

III. — THE TRIBES AND THEIR FLOCKS.

The tribes who include the Butana area in their wanderings may be divided into two categories. The first one consists of those who live permanently in the Butana, and even though they move from one place to another, all their movements occur within the Butana. There are others who roam temporarily in search of water or pasture, and occupy some areas in the extreme north or south for a short time, and return subsequently to their homes outside the Butana. This category does not concern us here, since its members are not, properly speaking, Butana people.

The main Butana tribes, as given in one of the main official reports, are the Shukria, the Lahawiyan, the Kawahla, the Kenanah, and a few minor groups (the Ahamda, Bawadra, Duwaihiyin and Khwalda). It will be useful to consider the principal among these groups.

The *Shukria* are divided into two large groups. The first is a large section which lives in the western Butana, their capital being the town of Rufa'a on the Blue Nile. Their number is considerable, perhaps in the neighbourhood of 80,000, and only 15 per cent of them are described as nomadic. They thus live in the Blue Nile Province, and their fixed homes lie close to that river. They occupy little of the Butana proper. The principal Shukria who occupy a very large part of the Butana have now their main headquarters in the town of Gedaref, and belong to the Province of Kassala, and they are of special importance to the present study and deserve special attention. In fact these are

now considered to be the Shukria proper, while those of the Blue Nile are just a branch. Both are headed by members of the famous Abu-Sin family, well-known from the writings of Samuel Baker, but the head of the Gedaref branch is no doubt the Senior Sheikh of the whole tribe.

Sheikh Mohamed Hamad Abu-Sin told the expert that the Shukria consisted of seven tribal sections. Five of them are in various stages of nomadism : these are the Butana section, the Lahawiyin, the Atbara, Abu Deliq and Kenanah sections. Two sections are completely sedentarised : the Abu-Sin section who live within and in the neighbourhood of Gedaref, and the Western Section.

He thus considers the Blue Nile Shukria as just one section of the larger Shukria tribe. He estimated the number of the whole tribe at about 200,000. Because of their numerical superiority, many other tribes of the Butana have attached themselves to the Shukria, who occupy such a predominant position in the Butana.

Most notable among such tribes are the Lahawiyin, a large camel-owning tribe, who used to live in Kordofan, west of the Nile, and were forced to emigrate to the Butana, and became close associates of the Shukria.

The administrative body of this region shows clearly the predominance of the Shukria. The district is known as the Rural Council of Northern Gedaref, and its chief is the « Nazir» of the Shukria, who does not concern himself only with his own tribe but also with the Lahawiyin and others whose territories extend over the greater part of the Butana, up to Goz Ragab in the east and Abu Deleiq in the west. This Nazir, who is also the President of the Council of Northern Gedaref, occupies a permanent post, presides over the meetings of the « Council», and wields considerable influence. He is paid by the Central Government, and is assisted by Officers from the Ministry of Local Government.

The present Nazir, Sheikh-El-Arab Mohamed Hamad Abu-Sin is an intelligent quiet gentleman, who is fully aware of the importance of helping the nomads to lead a more settled life. As President of the Council of Northern Gedaref, he has to look also into the affairs of several other tribes extending from Gedaref to the 16th parallel of latitude.

Previously, the Shukriyah had their headquarters along the Atbara, not very far from Khashm-el-Qirba. Their settlement was known as Asobri, and comprised about four to five villages, the principal one being Gafala which today is the flourishing « capital» of a Shukria Khutt (or tribal section). The headquarters of the Shukria, however, were moved to Khashm-el-Qirba, which remains another of their principal settlements. Their headquarters, however, were moved again to the town of Gedaref further south, and remains as such today.

One of the main duties of the leaders of tribes, the Nazir and his lieutenants, is to collect the taxes, which are assessed according to the size of the flocks. The following is the estimate received regarding the size of the flocks of the Shukria and their associates :

Tribe	Camels	Cattle	Sheep	Goats
Shukria..............	92,000	77,000	165,000	120,000
Lahawiyin............	114,000	6,000	97,000	65,000
Kenanah	20,000	2,000	3,000	25,000
5 minor tribes	33,000	18,000	33,000	24,000

These numbers are probably an under-estimate. The figures, however, clearly indicate the enormous size of the flocks. There is no doubt that the impression one gains of the inhabitants of Butana is one of prosperity and abundance.

The camel is naturally the most important possession. Its importance is not so much utilitarian as psychological. One takes pride in the ownership of camels : it is a sign of position, prestige and esteem, and there is hardly any reluctance to pay the tax demanded for their ownership. The Lahawiyin pay some £S. 30,000 annual tax. People are reluctant to part with their camels even for a good price. Because people value its possession for its own sake, a camel still fetches a good price, about £S. 50 or more. And yet its utilitarian value has considerably diminished. There are no longer any regular caravans from one town to another. The competition from modern means of transport has reduced

and almost destroyed the value of the camel as a common means of transport. The breeding of camels involves a lot of hardship and seasonal migrations and distant travel. Their meat is not valued even by the nomads, whose principal source of meat is their sheep and goats. Their milk is not very palatable, and on long treks cannot be stored or made into butter; much of it is spilled and thrown away. Yet love of camels is probably the greatest difficulty in persuading the true nomad to pursue a more settled life.

Camel herds exist only in the northern Sudan, but because the Sudan is usually approached from the north, the camel is often considered the principal symbol of the country. Thus the camel was printed on the first postage stamps to be issued. It is also stamped now on all copper and silver coins and printed on all the banknotes, whether of large value, such as ten pounds, or of small value, such as the quarter of a pound note. When a beer factory was established, the bottles carried the picture of the inevitable camel. Of all the picture postcards showing Sudanese objects, those showing camels form a very large proportion.

All those who admire the camel and would be sorry to see it disappear can be sure that there will always be areas in the Sudan, north of the Atbara, and in the north of Kordofan and Darfur, where the camel will always live and prosper. Here are lands where there can scarcely be any other means of existence save that of the nomads with their camels and sheep. But the Butana is not such an area; it is a land of good soil and water supply, which can prosper under an advanced form of economy, like agriculture and industry. The nomads themselves have given evidence of this by practising a kind of shifting agriculture, which yields a fair part of the millet they all need for their sustenance.

The animal picture is indeed changing; many nomadic groups are acquiring more and more cattle and slowly disposing of part of their camel stock. This is clearly the case with the Shukria, who already possess about 80,000 head of cattle and who all pursue some sort of irregular shifting cultivation, usually of millet. Breeding cattle turns them from tent-dwellers to dwellers in gutiyas, a conical-shaped dwelling made of wood and mud, and thatched with straw. Its low cost makes it ideal for those who cannot afford a more elaborate dwelling. It is excellent

for protection against sun and rain, and can be constructed in a short time at a cost not more than £S. 50 (the ordinary price for one camel). It could, of course, cost more, when its circular walls are made of stone or concrete and provided with windows.

There can be no doubt that gutiyas are increasing and tents are gradually decreasing in the Butana. The Lahawiyin are a good instance of this. Not many years ago they had only tents of camel and goat hair. Now they have built themselves a « capital» known as the Mukatta'a with fairly good gutiyas.

Once they live in these permanent dwellings, which form stable villages, they never abandon them, but if any movement is necessary they send some of their younger men to look after the animals. For cattle, sheep and goats, they need never go very far; but camels might take them a considerable distance, though never as far in the Butana, as in the Etbai, north of Atbara, or in Kordofan, west of the Nile. In the Butana, distances are smaller and wells more abundant, and the river Atbara is never very distant. There are a few interesting villages and towns with market places, where the nomads dispose of some of their animals and acquire the goods they need, especially grain and cooking utensils. Some may even invest in a radio and some simple furniture. There is no doubt that the Butana dwellers are not very far from ultimate settlement. No matter how delightful life may be in the wandering camp, with all its song and dance (advantages which could well be preserved along with sedentary life), the temptation is strong to stay in the village and get the benefit of medical and veterinary care, as well as some schooling for the children.

IV. — THE KHASHM-EL-QIRBA PROJECT.

The Sudan Government wishes to carry out a programme of settling the nomadic population in the best possible way. The letter received by the I. L. O. from the Sudan authorities invites a study of one settlement project, namely that of the nomads in the Qirba area, which, it is thought, might be a kind of pilot project to be applied gradually in other areas. The idea is quite sound, and there are certain principles concerning sedentarisation which are applicable in almost all cases.

But in addition, there will always be some conditions peculiar to some cases, and will call for special treatment. There are differences in both the physical and human elements and conditions which make every problem of settlement rather different from the other. It is thus important to approach every problem of sedentarisation with an entirely open mind.

One may begin by inquiring about the Qirba project and how it came to have a bearing upon the questions of settlement of nomads. It is possible that the project did not at first concern the nomads in any way.

The Khashm-el-Qirba Project consists of the following elements, none of which is complete as yet, but most of which are approaching completion; they may be taken each in turn.

1. In the first place there is the undertaking *to harness the waters of the Arbara*. This is the most northerly tributary of the river Nile and has a strong flood in the summer and early autumn. This project consists of a dam about four kilometres south of Khashm-el-Qirba. Part of the Atbara flood will be used to create a reservoir, holding about one milliard cubic metres of water, to be used in the long rainless season. Thus there is a *dam* and a *reservoir*, as the first fundamental elements in the project.

2. In the second place, *electric generators* are being installed which will supply all the electricity required for general purposes, and power for the sugar factory.

3. Thirdly, a *canal* which carries water, whenever required, from the reservoir lake to the irrigation areas further north, has been completed and extends for a distance of 26 kilometres from the river to the area to be irrigated. It then branches into two canals, an eastern and a western, to carry water to the fields.

4. Fourthly, *the land to be cultivated* has been limited in the first stage of development to 150,000 feddans [1]. But, seeing

[1] A feddan is roughly an acre.

Khashm El-Girba Irrigation Project
Preliminary Layout

True N.
KILOMETRES
MILES
Village
Sugar Factory
Pilot Scheme
Forests
III Agriculture Block
River Atbara
Es Sudeira
Sugar Factory
East Branch
West Branch
Escape Drain
Amara Abu Sin
Asubri
Kurraj
Pilot Scheme
Railway Line
Main Canal
Limit of Survey & Settlement
J. EL GARAB
El Qurashi
Saroba
Kosak
Butana Bridge
Station
Khashm El-Girba

that the land to be developed in due course is calculated to reach 500,000 feddans, the present limitation will probably not be observed, if for any reason there is a need for expansion.

These lands are, indeed, the main item in the whole project. They are to be cultivated by utilising rainfall water in the rainy season and irrigation water at other times. The land has, for this purpose, been divided into farms of 15 feddans each (one to be allotted to each household). Canals and irrigation ditches have been excavated. Already an experimental farm of about 100 acres has been established for conducting experiments as to the most suitable crops to be cultivated and for the selection of the best strains.

5. The next item in the Project concerns *the human element*. The decision has been taken that the inhabitants of Wadi Halfa in the extreme north of the Sudan, whose lands and houses will be inundated by the water of the Aswan High Dam, should be *the first to be settled* in the lands of the Khashm-el-Qirba Project. To them 125,000 feddans are allotted, and their settlement is the most important objective to be attempted in the first seven or eight months of 1964. The number of these Halfa citizens is probably some 50,000, and efforts have been exerted to meet all their needs in their new homes.

They will probably have to get used to a new environment and new crops, like cotton, wheat and groundnuts, and new methods of cultivation. Measures have been taken to provide the new settlers with full agricultural guidance.

6. Related to the above is *the housing problem*. A careful scheme has been planned and is being carefully and rapidly executed. It consists in the building of some 26 villages, which will mostly carry names of places in the inundated Halfa homeland. In the middle of the area a town, the new Halfa, with all city amenities will be established as the capital of the new district. The village sites have been chosen so that each village is quite close to the land it has to cultivate, and a farmer need not spend more than half-an-hour to get from his house to his farm. In view of the fact that the Halfa people will have lost their old

homes, they will take free possession of their new ones. The new houses are well built with specially fabricated bricks. Each house has four or five rooms and stands in 500 or 600 square metres of ground. It will certainly have adequate room for a family and a fair number of head of cattle, sheep, goats and poultry.

7. Another major element in the project is the construction *of a sugar factory*. This lies in the northern part of the area and has allotted to it some 45,000 feddans for growing sugar cane. The structure of this factory is nearly complete; the machinery is partly there and the rest on the way at the time of writing (January 1964). The peasants to cultivate the sugar cane are to be carefully chosen and the factory will give employment to those who prefer industrial occupations.

8. Last, but not least, the Khashm-el-Qirba Project provides, in addition, for allotting some 25,000 acres for the settlement of local nomads. This question, because of its bearing on the present study, will be given separate consideration.

To sum up the Project of Khashm-el-Qirba is nothing short of the creation, in an area which was scarcely inhabited at all, of a completely new settlement with all its requirements provided—water supply, electricity, drinking water, industrial plant, houses and roads, fields for cultivation, as well as a new population, transported by railway, part of which was specially constructed for the Project.

The question of settling the Halfa people in their new home, separated from their former one by nearly 1,000 miles, is an urgent one, with a definite schedule requiring that it should be accomplished before August 1964. Owing to some delay in constructing the villages, a delay for which the Sudanese authorities are not responsible, there is a great deal of activity in many departments, and the whole country is watching the fulfilment of this great project. Consequently, the settlement of the Halfa people takes precedence over every other consideration, including that of the nomads. This, however, does not prevent giving some attention to this matter, even though many responsible persons think it is not very urgent at the present time.

V. — SETTLING THE BUTANA NOMADS.

The I. L. O., as is well known, is committed to rendering assistance to every member State, which so desires, in carrying out *its own* programmes of sedentarisation for its population, and their integration in the national life of the country. The Sudan Government has asked to be helped in carrying out such a programme, with regard to the tribes affected by the Khashm el Qirba Project. It is clear, however, that a definite « programme» had not yet been completely worked out when the I. L. O. was approached by the Sudan authorities. In this connection, it is important to refer to a letter from the Under-Secretary of State for Local Government, Mr. Ali Hassan Abdullah, dated 22 May 1963, and written in Arabic and addressed to Dr. Abu Zeid. The following extracts from the letter should help in understanding the request made to the I. L. O.

The letter refers to the allotment of the 25,000 feddans *inside the project,* which should be utilised for the settlement of the « local» inhabitants, most of whom are described as nomadic, and refers also to the lands *surrounding the project,* which might also be developed. The letter further refers to the suggestion of the Executive Committee of Kassala Province that the settlement of the local people should aim at the establishment in those 25,000 feddans of a kind of mixed husbandry, including both agriculture and cattle breeding. In the latter activity, however, camels should be replaced by cattle.

The Under-Secretary further says in his letter : « As we do not know exactly the ways in which your Organisation might lend us its technical assistance, I leave it to you to determine that assistance. Perhaps it is appropriate that I should mention that there is need for an expert ' team' to be sent by the I. L. O. (to the Sudan) to study what help could be rendered in this important and vital project, which aims at the settlement of some 70,000 nomads, which has been made possible by the Project of Khashm-el-Qirba».

It is obvious from his reference to the need for the I. L. O. to send a team of experts to study ways and means of rendering assistance to the Sudan, that the authorities there have not yet worked out a detailed «programme» and that the I. L. O. is asked to help in working out such an activity.

In the circumstances, it was appropriate that, when the matter was discussed with the Minister of Labour during the International Labour Conference in June 1963, it was agreed that for the time being it might be sufficient to send just one expert to study the question on the spot and advise on the steps to be taken.

Both the Under-Secretary of the Ministry of Local Government and the Executive Committee of the Province of Kassala refer to the services to be rendered to the nomads as relating to two areas :

(*a*) the 25,000 feddans (acres) inside the project; and

(*b*) the lands surrounding the project. What the word « project» refers to is, of course, the land which will in due course be fully developed for irrigation and settlement, and which is planned to amount, when fully developed, to 500,000 feddans. In the first stage of development, however, the land utilised will be some 150,000 feddans, and the 25,000 should be part of that.

It is important to consider separately the 25,000 feddans inside the project and subsequently try to deal with the surrounding area :

(a) *The 25,000 Feddans.*

It is interesting to remember the circumstances which brought about the idea of giving the local nomads a place in an area which was primarily intended for settling the Halfa people. The area covered by the project was something of a no-man's-land, since no portion of the population was permanently settled there. There were, however, some enterprising nomads, or rather « semi-nomads», who were in the habit of practising a kind of shifting cultivation, which involved a brief occupation of a piece of land just long enough to sow their millet seeds, reaping the crop a few months later. Otherwise, the only use to which the land was put was for grazing their animals in the course of their

wanderings. The inhabitants of the area, however, though the idea of possessing land would not occur to them, did have a grievance, because the Khashm-el-Qirba Project did restrict the grazing area to the extent of 150,000 feddans, in the first instance, and 500,000 feddans when the project will be completed. Grazing rights of nomadic tribes being generally conceded, the tribe concerned in the project area was a section of the Shukria, and their allies the Lahawiyin. When they complained to the authorities, they were « compensated» by the grant of 25,000 feddans within the project. On these lands, however, they were not to practice the old system of shifting cultivation, or merely to graze their animals, but they have to pursue new methods of agriculture and some cattle breeding. Since they will have water all the year round, they would be required to give up their wanderings and live in permanent settlements. These ideas were mentioned to them orally, but were not fully grasped by many of them.

It must be mentioned that the Qirba Project has not caused the local nomads any serious hardships, largely because land is still plentiful in the Butana, whether for grazing or shifting agriculture. But it is not in the nature of the tribes to permit any encroachment on the lands of their wanderings without adequate protest. Thus they were promised as a compensation 25,000 feddans within the project. The promise was solemnly given, but steps have yet to be taken to give effect to the promise and to translate it into action. Nothing, however, has so far been done, and some time must elapse, perhaps a year, before anything can be done.

This is not due to any negligence or retardation on the part of the authorities, but to the fact that the project has primarily to serve the needs of the Halfa people, who must be settled, housed and fed, after transporting them to their new homes in the Butana. This is a problem of such magnitude that it is capable of occupying the time and energy of a great many administrative and technical departments, including irrigation, agriculture, forestry, transport, and many others.

Maps were supplied to the writer at his request, and he was particularly anxious to know which part of the project lands were allotted to the settlement of the nomads. It was noticed that the earliest map did

show sites for a few (perhaps about six villages in an area of about 25,000 feddans) in the northern part of the project. In the later maps, however, there was no clear demarcation to show where the Shukria portion was located, and when urgently asked on this question one of the greatest authorities on the irrigation of the project assured the consultant that this matter would be taken up as soon as the needs of the Halfa people are fully satisfied.

It would, however, be wrong to say that the 25,000 feddans exist only on paper. There is land enough and to spare, even if the initial amount of 150,000 feddans has to be exceeded. But time is yet required for deciding the exact demarcation of the land and for drawing up plans for the location of the different farms, the types of villages, canals and water supplies. In short, the amenities, or some of them which were made for the settlement of the Halfa people have yet to be carried out by the authorities for the benefit of the nomadic settlers.

The expert asked some of the leading authorities in the Sudan whether they intended to build for the Shukria the same kind of villages as they have made for the Halfa people. He was definitely informed that this was not contemplated, the theory being that the latter are losing their homes because of the High Dam and have a right to new homes, as well as other types of compensation. They argued that the Shukria will probably manage to build their villages in the same way as at present, namely by building gutiyahs or the conical huts, to which they were accustomed. The authorities would probably undertake such public buildings as schools, medical and veterinary clinics, places of worship and so on. The expert could not help noting these points of difference in the two types of settlements, and wondered whether something more could not be done for the nomads, if and when the time comes for them to move to their new homes.

Another point must be made clear. In the Khashm-el-Qirba Project some 26 villages are to be constructed, which should receive something like 32,000 inhabitants. In addition to the village, a central town will be set up to act as capital and will gradually receive some 10 or 15 thousands or more. This will all be included in the total area of 125,000 feddans. If the nomadic immigrants are given only five or six villages,

or an area one-fifth of that allotted to the Halfa people, the number of the immigrating nomads would be something in the neighbourhood of eight to ten thousand people. This number is only one-seventh of that mentioned in the letter of the Under-Secretary of State for Local Government referred to above. This will probably mean that the initial settlement would be devoted merely to the « local nomads», which might act as a kind of pilot project. The rest would presumably be accommodated in the area surrounding the project which will be considered later, and to which reference has already been made.

The so-called « local nomads» for whose benefit the 25,000 feddans are to be allotted, consist mainly of the Atbara section of the Shukria. They probably number some 20,000 or more, and they inhabit the area to the west of the Atbara. Khashm-el-Qirba village itself was part of their homeland and was at one time the capital of the Shukria. But Khashm-el-Qirba has grown under the project from a village of about 8,000 to a very busy town of 40,000 or more. The principal settlement of the local Shukria lies, however, in an area to the north of Khashm-el-Qirba village and is known as « Asubri». The main settlement is in a village known as Gafala, which is the present headquarters of the « Atbara» section of the Shukria.

The expert visited this village together with the Canadian expert on the Halfa settlement, and Mr. Hassaballah, the assistant Commissioner. They travelled by car and were received by the notables of the village. They toured the schools, of which there is one for boys and one for girls, the clinics, and the small mosque or Khalwa. The dwellings consisted of fairly well-preserved gutiyahs, some of which were built of stone and had small windows. Tents were completely absent, and they saw a lot of cattle but no camels. They were told that the younger members of the settlement were away to the south with the camels.

They had a very friendly talk, and, although the villagers were pleasant and hospitable, they did not fully study all sides of the question. They were under the impression that all that was expected of them was to cultivate the 25,000 feddans in the same old way as they did before the project, and they proposed to stay there a few days or weeks and then return to their villages. The old mentality still prevailed. When it was explained to them that some of them, at least a few thousand, will be invited to settle in new villages, where they will find sufficient water all the year round, that new crops like cotton, wheat, and groundnuts will bring them a lot of money, that they will be taught new methods of irrigation and cultivation, they were visibly impressed. It will probably take more persuasion before they are fully convinced.

But it must be admitted that the « local» Shukria are not really nomads, but only semi-nomads, of whom only one portion of the tribe wanders with the camels, while the rest lead a fairly sedentary life and have in addition to camels a good many cattle, sheep and goats. They are probably quite happy that they were promised those 25,000 feddans, and something should be done to enable them to understand the benefits of acquiring lands and of permanent cultivation. In other words, a process of community development and fundamental education is indispensable to prepare them for their new life. Thus, a programme of social service, to be initiated as soon as possible, is the first requirement of these people as a preparation for future settlement.

It is assumed that about half of the local Shukria would be moved to the new homes, while the rest will continue to live in the present villages, where some industries, dairy farming and carpet making might be developed. No action to coerce them to immigrate to the cultivated lands should be attempted, but their interest must be gradually aroused to the new type of life by means of education through social service.

There are other nomads in the area, like the Lahawiyin, who have lately become rather semi-nomadic on the Shukria pattern, and have built themselves a capital like Gafalah, and might be treated in the same way as described above. Some slight competition between the two tribes might help in bringing about a desire to move to the new land, with its adequate water supply.

(b) *The Lands Surrounding the Project.*

It has been shown in the preceding pages that the 25,000 feddans are not yet available. The other lands surrounding the project have been mentioned also in the documents received, and it is useful to examine

what is meant by the lands in question, since this was not absolutely clear from the previous communications received, and is one aspect of the problem which had to be examined on the spot.

In order to grasp fully the significance of this aspect, it is well to remember that the most important element in all questions of sedentarisation is that of the water supply. It is primarily by water that the nomad can be attracted and persuaded to settle down. Now it may be asked where is the additional water supply coming from to these surrounding lands, seeing that all water is at present going to the Qirba Project. The answer lies in the fact that, while the bulk of the water is going to the project, some water will be available west of the project in a long canal known as the « escape» or « drain». Thus, of the land surrounding the project, only the western side is at present contemplated; and it is thought desirable that these lands to the west of the project should be developed by utilising the water of the drain or escape.

Now what exactly is this « drain» or « escape» ? Reference has already been made to the fact that the water stored in the reservoir-lake, south of Qirba, is to be conveyed to the lands of the project by means of a canal which has already been built and extends to the north-west for 26 kilometres. Then it divides into two branches, one to the east and one to the west in order to carry the water to the eastern and western parts of the project. Just before the point where the two branches are bifurcated, there is a third water-course, a channel which branches off from the main canal and « runs» closely to the west of the lands of the project. At the point where it branches from the main canal, it is provided with gates, so that the water could only « escape» to this extreme western channel, when it is considered necessary to do so. The length of this « escape» is some 60 kilometres and may be extended further. Why has such a channel been constructed, when it does not carry any water to the project?

Apparently, the first motive behind the digging of this channel was as a protection against the inroads of nomads into the cultivated lands of the project, which would then be exposed to the wanderings of camels searching for pasture. According to this conception, the escape would get its water when there is abundant water in the main canal in the

rainy season when no water is required by the project, and water could then be safely diverted to the escape channel.

Afterwards some of those concerned with the economic and social development of the Butana began to think of the possibility of utilising the escape for irrigation and settling a large number of other nomads in permanent villages, for which water would be drawn from the drain or escape. Other authorities would be content to see nomads gather along the banks of the channel, to have a fairly adequate supply of drinking water for their flocks. Still others have argued that the channel would be a kind of long « hafir» with abundant water supply, which would effect a partial settlement of the nomads.

There are many who doubt that the channel could be utilised for irrigation, but a careful examination of the facts would seem to indicate that the « escape» would be full of water during the rainy months from June to September inclusive; and may in years of good Atbara flood receive additional water. Such waters will not be wanted during the rainy season, but will be useful afterwards for two or three months or even longer.

There is, however, one point which should be cleared with regard to the full utilisation of these lands along the banks of the escape, a point in which the assistance of the I. L. O. is eagerly sought.

The lands which might be settled here lie to the west of the drain or escape, and it is feared that they might slope towards the north in the whole project. In the project itself, which lies to the east, irrigation will be effected by natural gravity. But along the escape the land to be irrigated lies to the west or south-west, and water might have to be lifted from the escape and must further be carried by some pumping system to the land to be irrigated. On this problem, the Sudanese authorities have asked explicitly for the assistance of a surveyor or an agricultural engineer or both, to examine and survey the lands which are likely to benefit by the waters of the escape, and the necessary technical action to be taken to help carry the water to the lands, and to estimate the extent of such lands. It will be in the light of the findings of such an expert or experts, that further measures might be taken to invite nomads to settle in this area, and draw up a programme of assistance in this respect.

VI. — SUMMARY OF RECOMMENDATIONS.

In the preceding discussion it has been found useful to divide the recommendations into two parts in accordance with the division of the lands into those that lie within the project and those that lie in the neighbourhood of the project. The former concerns the « local nomads» mostly Shukria, and the latter concerns other nomads, not yet specified, of the Butana, which would probably include Lahawiyin and Kawahla (see Annex) as well as other Shukria.

In offering assistance to the local nomads in the Khashm-el-Qirba area, it is well to bear in mind that this will be a kind of pilot project, a model to be followed in other projects of sedentarisation in the Sudan. It is essential to recognise at the outset the principle of « integral approach», by which the essential services to be rendered should be carried out in close co-operation, in the fields of social improvement, agriculture, health, education and industry.

The team of experts which should undertake this task should be recruited by the I. L. O. and other competent U. N. agencies and should cover the main fields of activity. There are, however, two fields in which the Sudanese authorities could collaborate, because, they are already rendering a great deal of service therein, these are the fields of education and health, so that the Sudan Government should nominate experts on medical service and education to be members of the integrated service team.

Experts should, however, be supplied by the I.L.O. and other U. N. agencies in the following fields :

1. The *I. L. O. Chief of Project* who should be a highly qualified rural development and land settlement expert with knowledge of agriculture combined with social science and the necessary direct knowledge of problems of settlement of nomadic tribal populations including, if possible, a background in anthropology relating to these problems; his national counter-part would be a high-level co-ordinator having access to all the ministries and local government offices concerned.

2. *Social service*. The field of social service is a large one and should cover such activities as sports, village centres and clubs, home improvement and other well-known social improvement work. An international expert in this field has been solicited by many Sudanese. He should, however, be assisted by « national» social workers, to be recruited and paid by the Sudanese authorities, and should preferably include at least one woman. Their number should be somewhat flexible but should not be less than three social workers. They could be recruited from the Institute of Fundamental Education in Shendi, a town which lies on the borders of the Butana.

3. An *agronomist* or an all-round agricultural expert should do his best to improve the agricultural practices of the semi-nomads, introduce new crops, a knowledge of ploughing and use of fertiliser, etc.

He should be assisted by two national assistants to be recruited and paid by the Sudanese authorities.

4. An expert in *animal husbandry,* with a knowledge of veterinary medicine. His task would be to help in introducing better strains of cattle and sheep, to advise on new types of grass, and methods of obtaining milk.

He should also be assisted by two Sudanese nominated by the Government.

5. *Industry*. Some development of local industry is a very important element in the advancement of the community. An expert in this field is absolutely essential; among other requirements, this expert should have a thorough understanding of rural employment problems and should pay careful attention to the possibilities of developing additional employment opportunities, taking into account such factors as available local materials, capital resources, marketing situation, and the elementary skills of the nomads. He would naturally begin by a simple industry, for which raw material is locally available and for which no marketing difficulties exist. Perhaps a small workshop for making carpets would be the best to begin with. It should be fully equipped from the budget of the project. In choosing the type of industry local needs and aptitudes should be taken into consideration.

Two or three assistants should be nominated by the Sudan Government for this particular field. Other simple home industries could be encouraged, such as weaving cotton or wool, and a few looms could be lent to suitable persons.

It is therefore recommended that for this project a group of seven experts should be nominated, two by the national government and five by the I. L. O. and other specialised agencies.

6. *Equipment.* In all these activities, the U. N. agencies should help in providing essential equipment even in those fields for which a Sudanese expert will be nominated. It is rather difficult without further consultation and inquiry to give an accurate idea of what would be required. The following suggestions should be considered as tentative :

(a) *In the domain of Education :*

a small library—books as prizes for promising scholars, maps, pictures, etc.

(b) *In the domain of Public Health :*

simple surgical instruments—essential medical supplies, posters for health propaganda.

(c) *Social Service :*

(I) articles for such sports as volley-ball, basket-ball, table tennis; (II) some home improvement articles, like pans, cooking equipment, etc.

(d) *Agriculture.* Some equipment for ploughing, hoeing, threshing and reaping. Seeds for new crops, etc.

(e) *Animal Husbandry.* A sufficient budget should be allotted for buying new strains of sheep and cattle; artificial insemination, and a small dairy for making butter and cheese.

(f) *Industry.* In the first year the project budget should include the cost of setting up a small-size carpet workshop as an initial stage.

Such is the equipment recommended. It is perhaps advisable that a committee of experts should meet to decide on this question and streamline all the items required in all fields. Then if it could be decided that a lump sum for equipment should be provided in the project, based on the opinion of the experts, this method will permit of more flexibility.

It should however be added regarding equipment that the expert was particularly urged that the list should provide for adequate transportation because the present transportation resources are very strained. Two cars at least will be required, or a car and a lorry, for the project to be effective.

In concluding this outline of the main activities to be undertaken and the equipment required, it must always be remembered that this project is not merely for the benefit of the 10,000 odd nomads in the Central Butana, but it will have important consequences for benefiting the rest of the Sudan.

Work along the « escape-drain» should consist first of surveying the land, to discover how it slopes, and the degree of inclination of the surface. The I. L. O. might assist in carrying out this activity, by supplying one *expert* and one *surveyor,* to be assisted by some four or five young men, to be supplied by the Sudanese authorities. The details of such collaboration should be worked out before the work is started.

The second stage of the work will be done by an *agricultural engineer,* who, benefiting by the result of the surveying operation, should decide :

(1) whether the land could be irrigated from the escape-drain ; and what are the methods to be followed in undertaking such an irrigation ;

(2) the amount of land that could be cultivated by utilising the escape-drain ;

(3) suitable sites for villages, taking into consideration that each village will have some 3,000-4,000 acres of land to be used in a mixed-farming economy.

While the work of surveying could begin at any time, the rest of the work could not be accomplished until the rainy season is fully advanced and the escape drain has its maximum supply, so that its hydrography could be fully observed.

ANNEX

SOME ATTITUDES TO SEDENTARISATION

While it may be possible to find different points of view concerning the question of sedentarisation among the settled and sophisticated elements, it is interesting to note the attitude of the nomads themselves. In this connection two interesting experiences encountered in the course of this mission should be recorded.

The first incident occurred while discussing the problem at Gedaref, with the Nazir of the Shukria, Sheikh el-Arab Ahmad Hamad Abu-Sin, who is a great believer in sedentarisation. In the course of our conversation he mentioned that there was, some 30 to 40 miles from Gedaref, a section of the Musallamiyah tribe who have taken to a sedentary life *of their own accord,* without being obliged or persuaded. On or about 20 December the expert went to visit this group in their principal village. They lived in Gutiyas, which seemed well-built, and they insisted that they would never think of returning to a nomadic existence. They have disposed of most of their camels; and only keep what they have for the sake of transporting water. They asked the Nazir to help them in buying a tractor to develop their cultivation; and asked the present writer to help them in getting a *hafir,* so that they need not fetch water from a distance of 10 or 12 kilometres during the dry season. We were shown good specimens of large carpets woven by the women of the group.

The expert duly conveyed their request for a hafir to the proper quarters in Khartoum.

The second incident is even more interesting. The expert was sitting in the court of the rest house where he stayed at Khashm-el-Qirba, talking to some friends, on the evening before his return to Khartoum. Towards 7 p.m. an Arab in native dress, whom they did not expect, came to see them. He had in his hand a collection of papers, which turned out to be lists of names in about 45 pages. Gradually he began to explain who he was and the object of his mission. He belonged to a branch of the Kawahla tribe which lived in the northern part of the Butana, round the famous wells of Um Shedeida, some 200 miles away. His people

had heard that the « United Nations» had sent someone to the Sudan to help the nomads to settle down by giving them land and water. His people wished to declare their readiness to participate in this scheme, and to settle down. He answered definitely in the affirmative, when I asked him whether his people would cultivate the land, and dispose of most of their animals, particularly their camels.

The expert began to examine the lists. They were carefully and well written, carrying the names of each head of a household, followed by the number of his dependants. There must have been some 1,000 names, and about 10,000 dependants. Among the names was that of El Sharif Al Hindi, a well-known religious leader. He had the largest number of dependants, which was quite natural. The careful way in which the lists were drawn up shows that the desire was genuine. There was of course nothing that could be done for them at that time. It was even impossible for the expert to visit them in their homes. But he explained to the representative that a record will be kept of their names and their wishes, and their case will come up for active consideration in due course.

The expert left the lists in the care of the assistant officer of the Rural Council of Gedaref-North, and informed the competent authorities of the incident, which showed clearly that the applicants were genuinely interested in the prospect of leading a sedentary life. The expert was also naturally gratified that the initiative of the I. L. O. did not go unnoticed and the news of the mission even in a modified form had found its way to the homes of the nomads themselves.

WATER REQUIREMENTS FOR IRRIGATED AREAS IN THE FAYYOUM PROVINCE

BY

AHMED G. ABDEL SAMIE [1]

ABSTRACT

The demand for increasing agricultural production requires the improvement of the existing irrigation systems and methods, particularly in arid areas where water is the limiting factor, and the inadequacy of irrigation frequently causes salinity and alkalinity of the soil.

The determination of consumptive-use and irrigation requirements for different crops in the various farming zones is of basic importance in this respect. Among the numerous methods of estimating these values are those which are based on the use of climatological data.

The Fayyoum Province constitutes an area of approximately 307000 cultivated feddans. Its main water-feeding canals and drainage outlets are fairly controlled and hence the inflow-outflow method for estimating the water requirements for confined areas can also be used. The results obtained are compared with those calculated from the three formulae of Hargreaves, Blaney and Criddle, and Thornthwaite.

It is revealed that the total annual evapotranspiration from the cultivated area, as calculated by these three formulae are; 1971, 1088, and 928 million cubic meters, respectively. The difference between the water inflow and outflow amounts to 1698 million cubic meters, which is in close agreement with the consumptive-use values of Hargreaves'.

The correction of these evapotranspiration values for an average irrigation efficiency of 75% gives the amounts of 2628, 1450, and 1237 million cubic meters for the corresponding irrigation requirements. Hence, it is clear that the first figure is the closest to the three-year average of the total inflow which amounts to 2038 million cubic meters.

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It is concluded, therefore, that the Hargreaves formula gives more accurate estimates for the Fayyoum Province. The annual water requirements for the cultivated area, there, are 2628 million cubic meters which are approximately 30% more than the present water duties. The discussion revealed also that not only are the present irrigation duties inadequate, but also that their monthly distribution needs reconsideration. A proposed distribution based on the monthly PE values of Thornthwaite is presented. It shows that the water needed for irrigation in July and August, in particular, must be at least doubled.

I. — INTRODUCTION

The need for improved irrigation methods, efficiencies, timing, and application rates is much greater now than ever before. This is particularly true in arid and semi-arid areas where the water resources are somewhat limited, and the dependance of the agricultural development schemes on irrigation is vital. In these areas, the inadequacy of irrigation has hindered the chances of many fertile soils to produce crops economically. On the other hand, large areas have been degraded due to rising water table and increased salinity which resulted from over-irrigation. Therefore, a knowledge of the actual needs of the various crops to water in different zones is essential in planning the water budget for all irrigated areas.

The amount of water which is consumed by plant is influenced by many factors. The most important natural influences are ; climate, water supply, soil, and topography. Man is also a decisive factor as far as he influences the selection of an irrigation method, the preparation of land, and the application of irrigation water at the right time and with proper duties.

Various methods are used in estimating the irrigation-water requirements of new and existing irrigation projects. The actual measurements of the water-use by crops although they are the most accurate, yet they are expensive and time-consuming. Therefore, attempts were made to determine the use of water by crops from climatological data. Hantush (1959), in reviewing some of these attempts for measuring evapotranspiration, stated that « inspite of the shortcomings of these methods, many workers have summarized that these methods enable climatologists to estimate total evapotranspiration for a sizeable field more accurately than a soil scientist can mesure it».

The current study compares between estimated evapotranspiration values for the cultivated area in the Fayyoum zone, using three different formulae, and the total water-use as determined by the inflow-outflow method.

II. — METHODS OF ANALYSIS

1. Thornthwait's Formula (1957).

Based on the latitude and mean temperature, the relation between monthly temperature and potential evapotranspiration may be reasonably expressed by the following equation :

$$UPE = 1.6\ (10\ T/I)^{a}$$
$$PE = (b/30)\ UPE$$

where :

UPE = monthly unadjusted potential evapotranspiration in cms. (the month is of thirty days, such having 12 hours of possible sunshine).

PE = monthly potential evapotranspiration in cms.

I = the heat index which is the sum of the 12 monthly index values of i.

i = a monthly heat index which is a function of mean monthly temperature in degrees centigrade.

T = mean temperature in degrees centigrade.

a = an empirical exponent that depends on I.

b = an adjustment factor giving the duration of sunshine for the month and latitude considered, expressed in terms of a 12-hour day.

2. Blaney and Criddle Formula (1952).

This formula is based on the assumption that consumptive-use varies with the mean monthly temperature, the extent of daytime hours expressed

as monthly percentages of the total daytime hours of the year, and with the available moisture. This relationship is mathematically expressed as follows :

$$U = KF = \text{sum of } kf$$

where :

U	= consumptive-use of crop in inches for any period.
F	= sum of the monthly consumptive-use factors, f.
K	= empirical consumptive-use coefficient for the crop in the irrigation season or growth period.
t	= mean monthly temperature, in degrees Fahrenheit.
p	= monthly percent of daytime hours of the year.
f	= $(t/p)\ 100$ = monthly consumptive-use factor.
u	= kf = monthly consumptive-use in inches.

3. Hargreaves' Formula (1955).

This formula differs from the aforementioned ones as it combines the element of relative humidity, and is expressed as follows :

$$U = KE = \text{sum of } ke$$

where :

U	= consumptive-use of a crop, in inches, for the irrigation season or a stated period.
E	= the sum of the monthly values of evaporation or consumptive-use potential for the period.
e	= monthly evaporation in inches = $d\ (0.38\text{-}0.038\ h)\ (t\text{-}32)$.
d	= monthly daytime coefficient. (a monthly percent of daytime hours of the year of 8.33 is equal to an index of 1.0).
h	= mean monthly relative humidity at noon.
t	= mean monthly temperature, degrees Fahrenheit.
k	= monthly consumptive-use (evapotranspiration potential).

4. Inflow = Outflow (Stream Flow Depletion) Method (Israelsen 1950).

This method is usually used for valley consumptive-use estimation. It gives a measure of the sum of the waters absorbed by and transpired from crops and native vegetation and the lands upon which they grow, and that evaporated from bare land and water surface from the valley in a period of one year. Its application is possible where the amount of water entering a known area of land, the rainfall, and the outflow can be measured. Certain assumptions have to be taken concerning the subsurface flow past the points of measurements, and the capillary storage before and after the season of measurements. The following equation is applied :

$$U = (1 - P) - (G_s - G_e) - R$$

where :

U	= valley consumptive-use for a 12-months period.
I	= water flow into the valley in 12 months.
P	= yearly precipitation.
G_s	= ground water storage at the beginning of the year.
G_e	= ground water storage at the end of the year.
R	= valley outflow.

III. — CLIMATE

The Fayyoum zone has its own climatological characteristics since it constitutes a depression in the western desert close to the Nile valley. This depression falls between altitudes 29°34' and 29°2' north. It includes three meteorological stations located at the altitudes of -43, 8, and 30 meters above sea-level. A study of their data revealed that averages of the observational values from the last two stations, namely Qasr El-Gebali and El-Fayyoum, seem more representative for the climatic conditions in the depression and were therefore used in the current study. Table 1 (1) shows the averages for mean monthly temperatures, relative humidity, and rainfall. Values for the mean monthly daytime hours were obtained from «The economical Atlas of Egypt» (1928).

TABLE 1

SOME CLIMATOLOGICAL NORMALS
THE COMPUTED MONTHLY CONSUMPTIVE-USE FACTORS,
AND THE POTENTIAL EVAPOTRANSPIRATION VALUES
FOR FAYYOUM PROVINCE

Month	mean monthly values for; temperature °C	Relative Humidity % (h)	Day-time hours % (p)	Day-time coeff. (d)	Rain-fall (mms.) r	Cons.-Use factor e	Cons.-Use factor f	Potential evapotranspiration PE, cms.
January	11.3	40	5.99	0.72	1.5	3.43	3.16	1.69
February	13.4	33	6.91	0.83	2.0	4.82	3.81	2.13
March	16.4	28	7.42	0.89	1.5	6.97	4.60	4.26
April	21.0	22	8.68	1.04	0.5	11.45	5.96	7.76
May	25.4	21	9.53	1.14	1.0	15.32	7.32	13.62
June	27.1	21	10.62	1.27	—	18.78	8.63	16.95
July	27.8	25	10.37	1.24	—	17.74	8.62	18.94
August	28.0	27	9.78	1.17	—	16.64	8.10	17.67
September	25.5	31	9.11	1.09	—	13.15	7.14	13.04
October	22.7	33	8.09	0.97	0.5	10.04	5.94	9.46
November	18.3	38	7.17	0.86	2.0	6.87	4.68	5.30
December	13.4	41	6.32	0.76	5.0	4.0	3.53	3.30

IV. — IRRIGATION

The amounts of water which are delivered to the Fayyoum Province for irrigation range between 5 million cubic meters per day during Summer, and 8 million cubic meters per day during the flood season. Surface inflow is, therefore, available all year except in January and the total amounts are approximately 2000 million cubic meters per year. The distribution of water in the farm ditches is done in such way that every individual farmer receives his share during a fixed time which corresponds with the area of his farm. This is attained through the use of fixed weirs of standard heights and variable widths.

The stream flow during an irrigation rotation allows for alternating wet and dry periods of one week each. Water is delivered at high level for seven days to permit irrigation of 50 percent of the cultivated area. During the alternate week, the water in the main irrigation canals of this area is kept at low level. This rotation system is followed during the Spring, Summer, and flood seasons although the amounts of discharge vary with the season.

It has been reported, however, that the calculation of the above-mentioned water duties did not take into consideration some of the essential factors which affect the irrigation and profile-storage efficiencies, and consequently water requirements and irrigation frequencies, such as :

1. The very high porosity of some sandy soils.
2. The salinity of low-lying areas which require excessive water applications to produce crops economically, and to guard against secondary salinization of soils.
3. It is noteworthy to mention that many attempts to locate underground water of suitable quality for irrigation purposes have failed.

V. — SOILS

The cultivated soils in this depression may be classified as ancient alluvium deposits. They vary considerably with altitude in texture, salinity, alkalinity, and hydraulic conductivity. Soil survey reports by

the Ministry of Agriculture (1959, 1960) indicate that the magnitude of the unfavourable characteristics in soil increases towards the Quaroon lake. The integrated effects of these characteristics are shown by the low productivity of such soils. According to the economic classification of cultivated land (U. A. R. Ministry of Agriculture, 1958) the farmed soils of Egypt were classified into five classes. Four of the five districts in Fayyoum, totalling 264000 feddans, fall within the fourth class while only one district, 42000 feddans, belongs to the more productive class three.

VI. — RESULTS AND DISCUSSION

1. Consumptive-use factors :

The calculated values for monthly consumptive-use factors, *e* and *f*, are shown in Table 1. Monthly values for the potential evapotranspiration, PE, are also presented. The *e* and *f* values are plotted separately for the twelve months of the year in figure 1. A study of this figure reveals the following :

a) the monthly consumptive-use factor of Hargreaves' and that of Blaney and Criddle are almost identical for January. The differences between them increase progressively in the following months until it reaches a maximum in June. During this month, the « *e*» value is more than twice that of «*f*», being 18,78 and 8,63 respectively. After June, the difference narrows again to a minimum after December.

b) Since the « *e*» and «*f*» values are directly correlated with the consumptive-use amounts, « *u*», it follows that the water requirements as estimated from the first factor reach approximately double that which are obtained by using the second factor, «*f*». This difference is particularly clear during the irrigation months between April and October.

c) The seasonal consumptive-use factors E and F, and the potential evapotranspiration PE were calculated for the main crops as shown

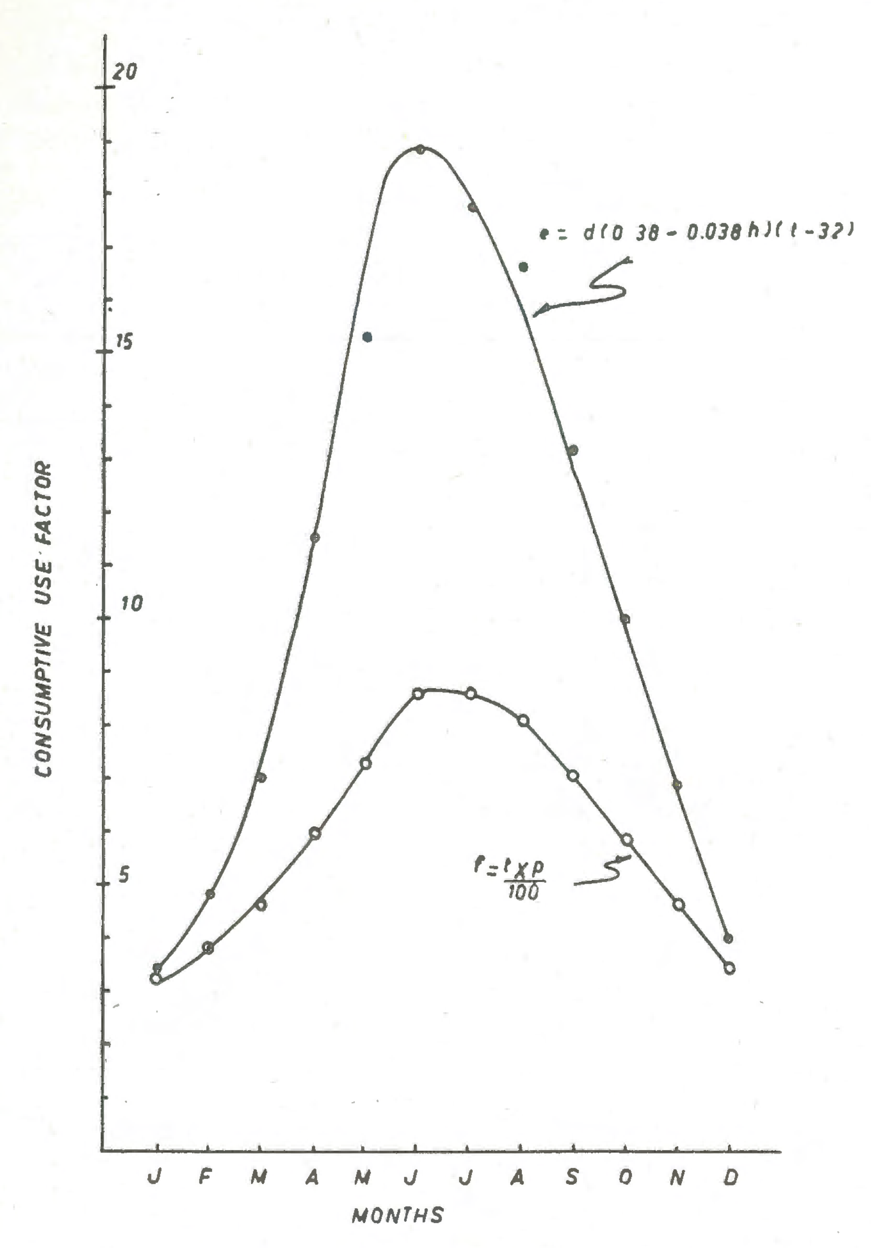


Fig. 1. — Showing Variations of the Monthly Consumptive-Use Factors, *e* and *f* in the Fayyoum Zone.

in Table 2. The selected growth seasons for these crops indicate the average periods between planting and harvesting dates. In this connection, the actual farmers' practices and results of agronomic experiments on the optimum planting dates were consulted. The differences between « E» and « F» are quite clear particularly for Summer growers such as cotton, rice, sorghum and early vegetables.

TABLE 2

SEASONAL CONSUMPTIVE-USE FACTORS AND POTENTIAL EVAPOTRANSPIRATION VALUES FOR THE MAIN CROPS IN THE FAYYOUM ZONE

CROP	GROWTH SEASON	Seasonal Consumptive-use factors		Seasonal PE cms.
		E	F	
Wheat	Nov. 15-May 10	39.22	25.89	26.33
Barley	Nov. 15-April 30	34.11	23.40	21.79
Beans	Oct. 25-April 10	31.58	22.76	21.11
Clover	Oct. 10-May 15	51.90	33.36	37.66
Summer rice	May 16-Oct. 10	77.31	38.13	76.68
Late rice	Aug. 15-Nov. 25	37.24	21.03	36.04
Cotton	Feb. 15-Aug. 15	81.09	41.09	71.07
Corn (Maize)	July 15-Nov. 15	52.14	27.83	52.60
Sorghum (early)	May 1-Aug. 20	62.94	29.97	60.91
Sorghum (late)	July 15-Oct. 15	43.68	22.52	45.37
Winter vegetables	Nov. 15-April 15	28.39	20.42	17.91
Summer vegetables	May 1-Sept. 1	81.63	38.81	67.18
Late vegetables	July 1-Oct. 15	52.55	26.83	54.53
Fenugreek (Helba)	Oct. 25-April 5	29.67	21.99	19.81
Orchards	Mar. 1-Feb. 28	129.21	71.49	114.15

2. CONSUMPTIVE-USE OF WATER :

The computed consumptive-use values are shown in Table 3, for each of the main crops. The consumptive-use coefficients « K» for these crops were taken from various references. Since these values vary, sometimes within a fairly wide range for the same crop, the highest

reported values were used in the current work. Meanwhile, it was not feasible to report on the monthly consumptive-use, *u*, because of the lack of adequate local experimental data on the consumptive-use coefficients, K.

Corresponding potential evapotranspiration values which were calculated from Thornthwaite's formula are presented in the same table.

TABLE 3

CALCULATED SEASONAL CONSUMPTIVE-USE AND POTENTIAL EVAPOTRANSPIRATION, AS COMPARED WITH ESTIMATED IRRIGATION REQUIREMENTS FOR CROPS IN THE FAYYOUM ZONE

CROPS	seasonal consumptive-use coeff. K	calculated seasonal consumptive-use, m^3/fed.		calculated seasonal potential evapotranspiration PE.	estimated irrigation requirements from experimental results [1]
		U=KE	U=KF		
		m^3/fed.	m^3/fed.	m^3/fed.	m^3/fed.
Wheat	0.68	2845	1874	1107	1230
Barley	0.68	2474	1697	916	1290
Beans	0.70	2358	1699	888	970
Clover	0.85	4707	3025	1583	2730
Summer rice	1.20	9896	4880	3222	8800
Late rice (Nile)	1.20	4766	2692	1515	5500
Cotton	0.65	5623	2849	2986	4030
Corn (Maize)	0.75	4172	2228	2210	2920
Early Sorghum	0.70	4700	2238	2559	not-dtnd.
Late Sorghum	0.70	3262	1681	1907	» »
Winter vegetables	0.70	2120	1477	753	» »
Summer vegetables	0.70	6096	2973	2823	» »
Late vegetables	0.70	3924	2003	2292	» »
Fenugreek (Helba)	0.70	2216	1642	933	» »
Orchards	0.60	8270	4576	4794	» »

[1] Data supplied by the water research division, Ministry of Public Works. (Memeographed in Arabic).

These latter values were obtained by adding the monthly PE amounts during the same growth periods for the various crops. They indicate that except for cotton, sorghum and late vegetables, the PE values are the lowest. In many cases, however, they are close to the « U» values which are obtained by using Blaney's formula.

The same table includes also, for comparison, some of the estimated values for the water requirements in the Mid-Egypt zone which includes the Fayyoum area. These estimates are based on actual measurements taken on some experimental plots located in the Nile-delta (Ministry of Public Works, 1960). It must be remembered that these values represent irrigation water amounts while the « U» values in the same table are only consumptive-use. Consequently, corrections for the quantities of effective precipitation and irrigation efficiencies must be applied in order to reach comparable values. Normally, then, it would be expected that the former values which are reported in the last column of the above-mentioned table are higher. Yet, it is clear that they are lower than either of the « U» values computed from climatological data for wheat, barley, beans, and Winter crops in general. For Summer crops, these values are in close agreement with the consumptive-use values of Hargreaves.

3. Inflow-Outflow :

Data of inflow and outflow were supplied by the department of irrigation, Fayyoum zone, and are presented in Table 4. Inflow records were usually taken as averages for each 10-days intervals but they are reported in the table as monthly values. The outflow amounts represent total monthly discharges from the two main drains in the province. Data on the level and fluctuations of the water-table are lacking. It is understood, however, that except for some low-lying areas near the lake, the water-table is below 120 cms. from the surface. In addition, its level is fairly constant throughout the year. Hence, and with the previously mentioned assumptions in mind, the differences between the inflow and outflow amounts were taken as measure of the consumptive-use of water for the province.

TABLE 4

MONTHLY INFLOW-OUTFLOW RECORDS FOR THE FAYYOUM-DEPRESSION AREA

1958-1960

(VALUES ARE REPORTED IN $M^3 \times 10^6$)

Month	1958			1959			1960		
	Inflow	Outflow	Balance	Inflow	Outflow	Balance	Inflow	Outflow	Balance
Jan....	30.168	18.950	11.218	35.600	19.327	16.273	27.227	18.451	8.776
Feb. ...	149.884	21.124	128.760	158.224	23.827	134.397	164.811	24.165	140.646
Mar. ...	182.351	23.770	158.571	158.630	24.958	133.672	183.266	28.326	154.940
Apr. ...	163.765	22.504	141.261	160.922	22.335	138.587	149.928	27.634	122.294
May. ...	161.269	23.750	137.519	153.124	22.943	130.181	150.535	29.832	120.703
June...	179.244	17.226	162.018	186.566	18.361	168.205	190.368	21.682	168.686
July...	219.945	20.450	199.495	209.803	21.068	188.735	212.984	20.561	192.423
Aug...	246.480	30.708	215.772	228.411	31.816	196.625	221.884	33.617	188.267
Sept...	210.442	37.590	172.852	210.780	35.483	175.297	201.214	34.982	166.228
Oct. ...	189.929	37.218	152.711	211.437	42.316	169.121	214.269	39.814	174.455
Nov. ...	165.924	35.897	130.027	161.356	36.421	124.935	178.018	38.531	139.487
Dec. ...	154.501	36.875	117.628	148.129	35.673	112.456	143.871	42.643	101.228
Total...	2053.902	326.060	1727.842	2023.012	334.528	688.484	2038.375	360.238	1678.137

Average inflow = 2038.430 million m^3/year.
Average outflow = 240.275 million m^3/year.
Average Balance = 1698.155 million m^3/year.

The average monthly inflow, outflow, and balance values are plotted for 12 months in Figure 2. The curves in this figure indicate the following :

a) The discharge of water (inflow) and the differences between inflow and outflow, which are assumed to coincide with the consumptive-use, both follow the normal magnitude of evapotranspiration throughout the year.

b) The outflow records indicate somewhat steady discharge which, except for June and July, marks a slight gradual increase towards the end of the year. In the meantime, and while they do not correlate with the amounts of inflow, they show a drop in June and July months in which the average inflow rises rapidly.

The rise of outflow between June and August is only little compared with the amounts of inflow during the same period, being approximately 13 and 47 million cubic meters respectively. It is reasonable to conclude that the measured inflow was barely enough, if not inadequate, to satisfy the crops' requirements during the above-mentioned period. Otherwise, the excess amounts would have shown in the drains since the capillary storage capacity of the soils is somewhat fixed.

The question of whether the irrigation-water amounts are ample or not requires detailed experimental work. Yet, the crop-production ratings for the Fayyoum province being third or fourth as compared with the national averages may be partly due to the inadequacy of irrigation. This argument is further supported by the following explanation. During the Summer months when the normal water discharge of the Nile is ample, particularly in April and May, the share of the Province amounts to five million cubic meters per day. Since the cultivated area is approximately 307000 feddans, then the water duty during these two months is about 16 m³/feddan/day. Regarding that the irrigation rotation allows for one water application every two weeks, then the water duty in each irrigation cycle of 14 days is only 220 m³/ feddan. It is true that the average crop need for water in April and May could be satisfied by these amounts. Yet, even in June and July when the demand for water is at its peak, the discharge ranges between 6 and 7

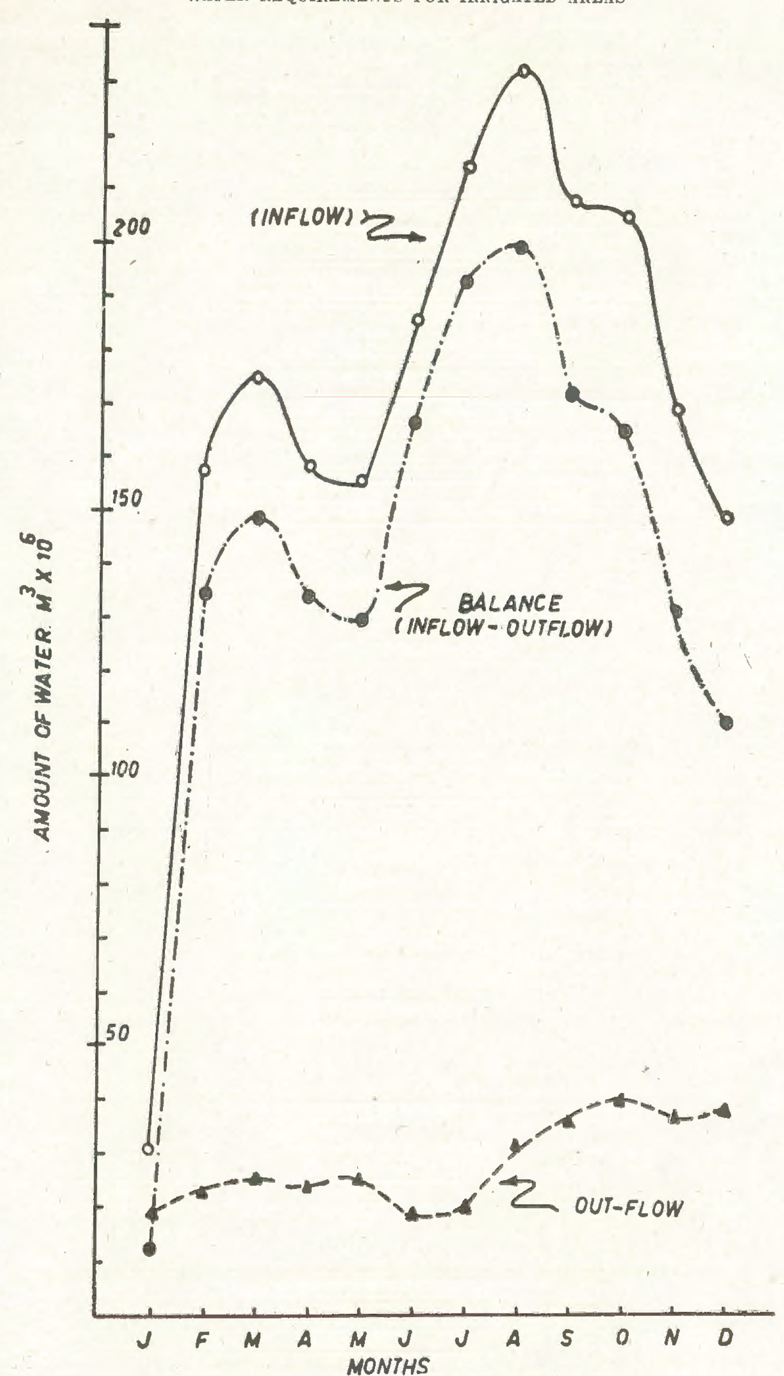


Fig. 2. — Average Monthly Variations of water inflow and outflow for the period (1958-1960).

million cubic meters per day which is equivalent to 19.5 to 23.0 cubic meters per feddan per day. It is believed that the latter amount which is equivalent to about 0.5 cm. (0.2 inch) per day is the minimum water-use under the prevailing soil, water, and climatic conditions in El-Fayyoum. For optimum production of crops, therefore, this amount should be increased.

4. Inflow-Outflow vs. PE :

The calculated maximum monthly PE values are compared with the monthly differences between inflow and outflow amounts as shown by the curves in Figure 3. The shapes of these curves indicate the following :

a) During the early part of the year, February to May, the actual water input is much greater than what may theoretically be lost by evapotranspiration. This is natural because during this period excessive amounts of water are normally needed to refill the capillary store in the soils after the dry Winter season, and also for preparing the land for cultivating Summer crops. Such pre-planting irrigation amounts are hard to calculate and their estimation relies upon the experience of local irrigation and agriculture engineers.

b) The opposite is true during the critical period between May and August. The balance amounts are markedly below the calculated PE values particularly in July. This is apparently when the inadequacy of irrigation occurs.

c) In the late part of the year, between September and December, there seems to be more inflow than required.

Needless to say that there are many factors, on which the aforementioned calculations are based, that may effect the results. Some of these factors are; variations in the planting and harvesting dates, and the size and type of the active transpiring area. In addition, it must be remembered that the balance values, herein reported, indicate the maximum amounts that are assumably retained in the soil for consumptive-use, and the PE values are the maximum needed to replace the actual losses from the soil and vegetative cover.

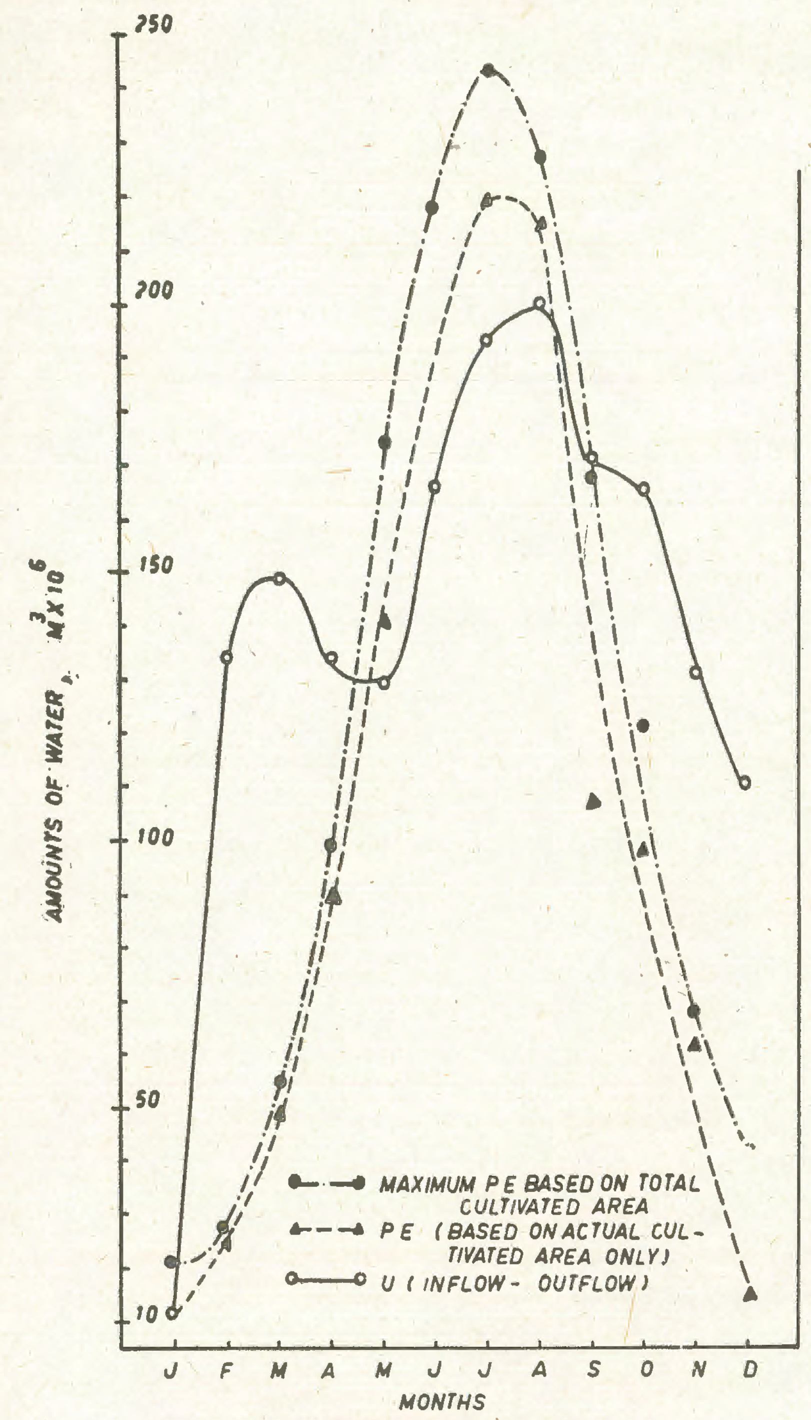


Fig. 3. — Calculated Monthly potential evapotranspiration and corresponding difference of inflow-outflow.

Table 5 shows a summary of the computed total consumptive-use and PE for the cultivated areas in the Province. These values indicate that the « U» values of Blaney and Criddle are fairly close to the PE of Thornthwaite, while the « U» values of Hargreaves are almost double the former amounts. In the meantime, the difference between inflow and outflow amounts compare fairly well with the « U» values of Hargreaves.

TABLE 5

Computed Total Consumptive-Use and PE from the Cultivated Areas in the Fayyoum Province

CROPS	Cultivated area, fed. in 1959.	Calculated Total consumptive-Use; M³ XIO⁶		Potential evapotranspiration (PE) mill. m³	Inflow minus Outflow
		U = KE	U = KF		
Wheat	107664	306.304	201.762	119.184	—
Barley	7671	18.978	13.018	7.027	—
Beans	14445	34.061	24.452	12.827	—
Clover	34193	160.946	103.434	54.128	—
Rice, Summer	7646	75.665	37.312	24.637	—
Rice, Late	14698	70.051	39.567	22.265	—
Cotton	81209	456.648	231.364	242.490	—
Corn	108906	454.356	242.642	240.682	—
Sorghum, Summer	11086	52.104	24.810	28.369	—
Sorghum, Late	48377	157.806	81.322	92.255	—
Vegetables, Winter	3825	8.109	5.650	2.880	—
Vegetables Summer	2444	14.899	7.266	6.899	—
Vegetables, Late	5930	23.269	11.878	13.592	—
Fenugreek (Helba)	6778	31.951	11.129	6.324	—
Orchards	11349	105.734	51.933	54.407	—
Total...		1970.881	1087.629	927.966	1698.155
Irrigation Requirements (based on 75 percent irrigation efficiency)		2627.840	1450.170	1237.280	2038.430*

* Inflow.

TABLE 6

Suggested Distribution for the Monthly Irrigation Water Needs as Compared with the Present Inflow in the Fayyoum Province

	Cropped Area, in thousand feddans	Potential evapotranspiration cms.	Rain fall cms.	(PE) minus Rain fall cms.	Total PE minus Rain fall m³/ 10⁶	Suggested Irrigation (1) Requirements m³/ 10⁶	Average Present Discharge inflow
Jan.	186	1.69	0.15	1.54	12.0	27.9	31.0
Feb.	276	2.13	0.20	1.93	22.4	52.1	157.6
March	276	4.26	0.15	4.11	47.6	110.8	174.7
April	276	7.76	0.05	7.71	89.4	208.0	158.2
May	256	13.62	0.10	13.52	145.4	338.3	155.0
June	114	16.95	0.00	16.95	81.2	189.0	185.4
July	276	18.94	0.00	18.94	219.6	511.0	214.2
August	292	17.67	0.00	17.67	216.7	504.3	232.3
Sept.	197	13.04	0.00	13.04	107.9	251.1	207.5
Octob.	252	9.46	0.05	9.41	99.6	231.8	205.2
Nov.	307	5.30	0.20	5.10	65.8	153.0	168.4
Dec.	186	3.30	0.50	2.80	21.9	51.0	148.8
Total ...		114.12	1.40	112.72	1129.5	2628.3	2038.4

(1) Based on 2628 × 10⁶ m³ for the whole cultivated area in the Fayyoum Province zone as calculated from Hargreaves formula.

The aforementioned discussion reveals that the present irrigation duties in The Fayyoum Province are inadequate, and that the values computed from Hargreaves' formula are more appropriate. Hence, the water requirements for irrigation in the Province should be increased to 2628 million cubic meters per year.

In order to use this water more economically, and to satisfy the needs of crops for water during the period of peak demand, the present monthly distribution must be corrected. A sound basis for this correction is the monthly PE values in the area. This is presented in Table 6 which gives the suggested distribution of the monthly irrigation-water needs as compared to the average present inflow. It is clear from this table that excess amounts of water are given in the early quarter of the year while there is a big water-deficit in the July and August months.

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ON THE ARTESIAN WATER

OF

NEJD, SAUDI ARABIA

BY

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The discovery in 1953 of artesian water in the north central part of Nejd introduced an interesting feature in the physical and economic geography of Saudi Arabia.

This entirely new water supply was discovered, by mere chance by, a Nejdian farmer while he was deepening his old well in *El-Zarka* village, near Buraida, capital of the Qassim Province. To his great surprise a prolific flow of water appeared suddenly at the ground surface when a depth of less than 100 meters was reached. The flow continued at a constant rate. Artesian water was discovered.

Since then a large number of successful borings (+200) have been made in different parts of Qassim, i. e. the part of Nejd lying roughly between latitudes 25°30' N. and 27° N. and longitudes 43°30' E. and 44°30' E. (Fig. 1).

GEOGRAPHICAL AND MORPHOLOGICAL CONDITIONS

This part of Nejd is a plateau of very small relief. From a geomorphological point of view, it consists of a magnificent series of cuestas moulded by erosion in the gently dipping strata of late Palaeozoic and early Mesozoic age. The dip is to the east and its amount is of the order of only 2°-3°. The remarkable uniformity of dip in the whole « interior homocline» of Arabia has often been stressed and Qassim is no exception, the country being almost a structural flat.

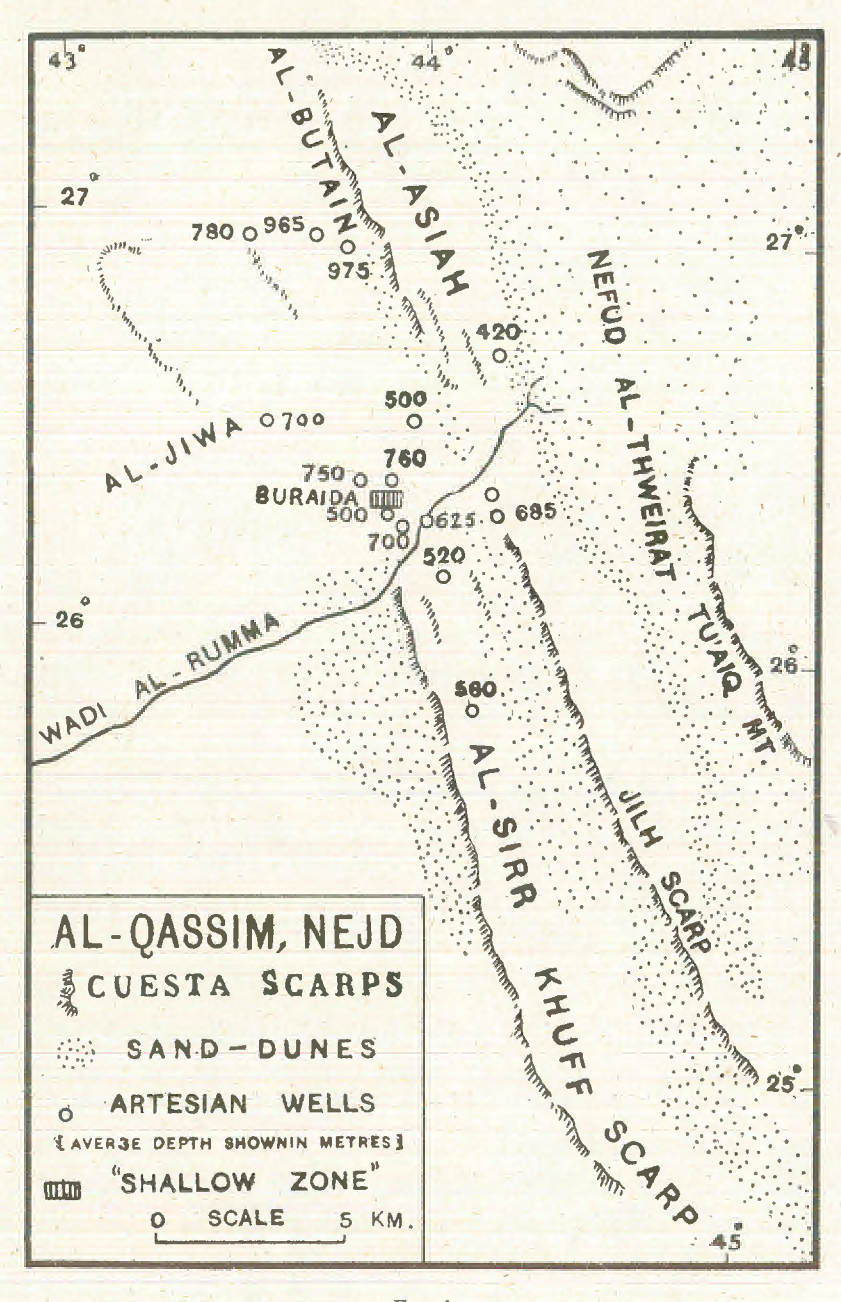


Fig. 1

Wadi Al-Rumma, the largest wadi in the Arabian Peninsula, crosses the central part of the area. Formerly it reached the head of the Persian Gulf, but its course has recently been cut across by the huge sand-dunes moving from the north, and its water, whenever it runs, now disappears eventually at the western extremity of the dunes, just east of Qassim.

Sand dunes, of various forms, constitute a prominent feature of the surface. The most important accumulations extend along the foot of the cuesta scarps, taking, therefore, a N.W.-S.E. general trend. Many dune accumulations occur in smaller dimensions in most other parts, as e. g., in the Buraida area where the interdune areas (Khubub of the natives) are untilised for cultivation of dates, grains and vegetables.

GEOLOGY

Fig. 2 shows the different formations of the Palaeozoic Era and the Triassic Epoch in Saudi Arabia [1]. The oldest outcrops in the producing area of Qassim belong to the Khuff Formation (Permian) which forms the cuesta scarp extending west of Al-Sirr zone (Fig. 1). The limestone of this formation can also be seen outcropping some distance further east in Al-Sirr zone itself [2]. The parallel cuesta scarp lying east of Nefud Al-Sirr, i. e. the Jilh Scarp, belongs to the Jilh Formation of lower Triassic age. The producing area is confined between the Khuff and Jilh formations, a remark which evidently gives a clue to the relative age of the artesian reservoir formations down below the surface. It must, however, be pointed out that several unconformities of large scale truncations have been observed in the sedimentary sequence in Nejd. In Al-Sirr zone the Khuff Formation lies unconformably on the Saq Sandstone, one of the main reservoir formations of artesian water in Qassim.

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(1) Compiled from Max Steinke, R.A. Bramkampf, and N.J. Sander, «*Stratigraphic Relations of Arabian Jurassic Oil*», Habitat of Oil, The American Association of Petroleum Geologists, June 1958, pp. 1294-1329.

(2) This remark as well as other remarks concerning the surface geology of the area are from the author's field notes. No geological map of Qassim has been published, but the structural and lithological conditions in Qassim are so simple and clear that they can easily be discerned even by a non-professional geologist.

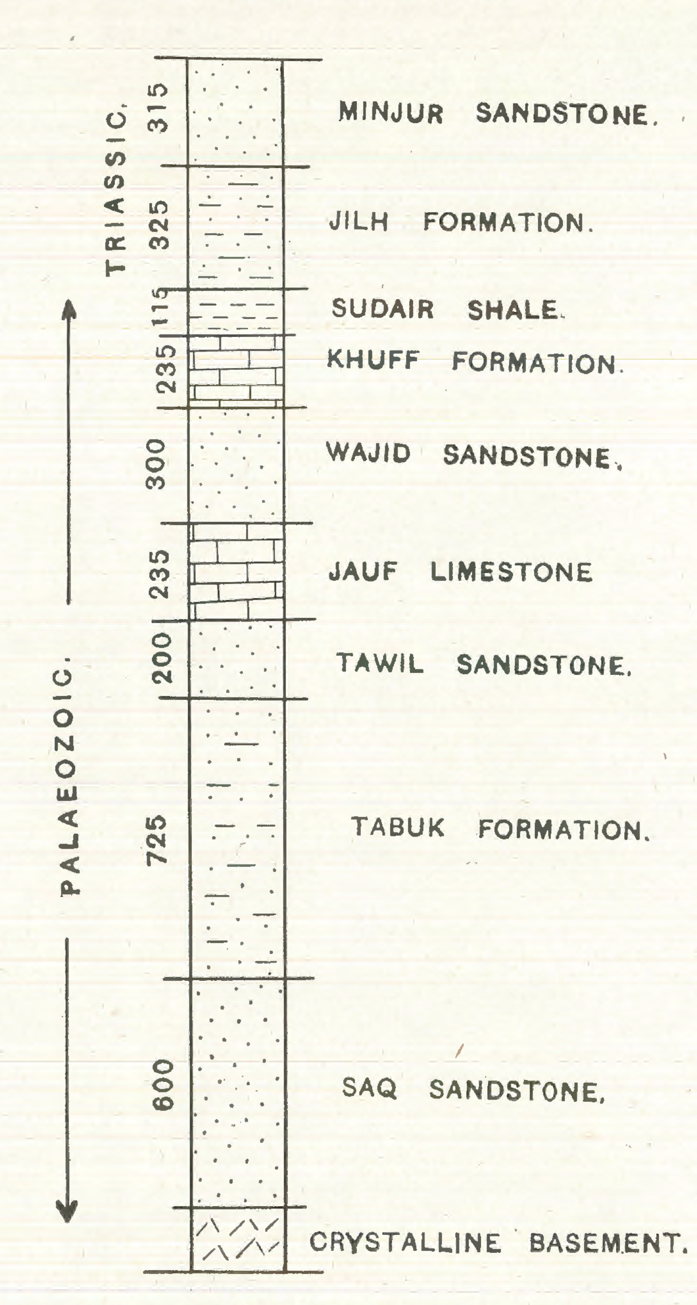


FIG. 2. — Formations of the Palaeozoic and the Triassic epoch in Arabia «thikness shown in meters».

SUCCESSFUL BORINGS

Before the discovery of this new water supply irrigation water was obtained from ordinary wells, 10-20 meters deep. Water was lifted by pumps, after the old device of animal—drawn « saqias» had been abandoned. In the lower part of Wadi-Al-Rumma, particularly in the Uneiza area south of Buraida, another source of irrigation water was the wadi fill, where water can be obtained at a depth of some two meters.

These two sources still persist in Qassim but, during the last five years in particular, the use of artesian water has spread at an amazing speed. Mechanized agriculture followed, sometimes in areas which have never known cultivation before. To quote the main example, the Doghmania plantation, more than 2000 acres in area, lies in Al-Butain area, formerly a land of wilderness the aridity of which is proverbial in Nejd.

The location of the areas where artesian water has been discovered and utilised and the average depth of the producing wells, as shown in Fig. 1, are based on data obtained by the writer during a trip in Qassim in 1962. It will be noted that the artesian water table ranges from 400 to 1000 meters approximately.

The only exception lies in a small area covering the northern quarter of the town of Buraida and extending as a narrow strip to the north and northwest. Artesian water is here encountered at an average depth of only 150 meters. We shall later refer to this area as the « Shallow Zone».

Incidentally, it was in the Shallow Zone that the first discovery of artesian water was made. The « hunt» for water naturally attained its climax in this particular area and an abnormally large number of wells have been drilled. Unchecked flow from these wells has caused surface water levels to rise in the area at an alarming rate. Ponded water and swamp areas are becoming quite common and damage has already been done to some fields and mud houses. This problem of rising water level is, however, confined to the Shallow Zone, since propor drilling and casing has been the rule elsewhere.

Water qualities differ. The water of the artesian wells lying east of the Buraida zone (as, e. g., in Tarfiya, Rubai'ia and Shumasiya), as well as those lying in the north eastern part of Qassim, i. e. in Al-Asiah zone, contains certain gases and is rather brackish, but it serves the purpose of agriculture. The western wells, mainly those of the Buraida and Al-Jiwa zones, produce water of a better quality, even though it is not devoid of impurities. The water is in places of a corrosive character and much damage has therefore been done to the casings of wells.

With the strong hydraulic pressure under which the water is discharged, the wells are highly productive. A flow of 500-600 gallons per minute is common. In many wells the discharge is much higher attaining 1000 or even 1200 gallons per minute, as, e. g., in many wells in the Shallow Zone. In few cases, especially where the wells were improperly drilled, a much smaller flow has been observed.

It will also be noted that in areal distribution, producing areas are of a patchy character (Fig. 1). This is partly due to geographical surface conditions, there being no wide and continuous areas of suitable soil and suitable relief. Another causative factor is the apparently discontinuous distribution of the artesian water itself. We could not obtain a full record of the unsuccessful borings in Qassim, but some examples may be cited. Repeated efforts failed to attain the artesian water table in the country extending south west of the Buraida area. In the town of Uneiza drilling attained a depth of some 1000 meters and then was abandoned on meeting with very hard rock, but near-bye, free-flowing wells, as e. g. in the bottom of wadi Al-Rumma, are producing from a much smaller depth. Another failure occurred in Abal-Dud in the northern part of Al-Asiah, although high production has been obtained in southern Al-Asiah, less than 30 kilometres to the south and in Al-Butain at a similar distance to the west.

SOURCE OF THE ARTESIAN WATER

The particular sub-surface structure that favours the strong flow of artesian water in Qassim is not known, there being an almost complete lack of geological and hydrological studies of the area. In Nejd deep

drilling has so far been confined to Qassim and the Riyadh zone. In the latter no artesian water was obtained from the wells that have recently been drilled to a depth of some 1000 meters.

Possible water—bearing strata include the lower members of the Khuff Formation of Permian age and, of course, the thick Saq Sandstone of Cambrian age (Fig. 2).

The main source area should be sought in the Hejaz Highlands in Western Arabia. Part of the runoff of these highlands flows eastward and should contribute underground water to the porous Palaeozoic formations which dip eastward, extending as they do under the surface formations of Qassim. There is little doubt that much of this underground water dates from the Pluvial Period to which we should assign the excavation of such a large valley as the Rumma. The rains in Nejd must also have then been much more abundant than at present.

We venture to add Wadi Al-Rumma itself as a third possible source. During the Pluvial Period this wadi, then a full-fledged river, debouched at the head of the Persian Gulf where deltaic deposits indicate the former presence of a vast delta. With the onset of the present arid conditions moving sand-dunes made their appearance and soon cut across the course of Al-Rumma just east of Qassim where they constitute a natural dam (Fig. 1). Infiltration of part of the Rumma water to porous subterranean horizons in the Qassim area has thus been enhanced. This should provide an explanation of the relative abundance of the ordinary underground water of the area (as compared, for instance, to the thirsty Sudair Province extending east of the northern Tu'aiq mountain), but some of the Rumma's water should have also reached deeper horizons to constitute an additional source to the artesian reservoirs.

THE « SHALLOW ZONE»

A particularly interesting feature is the relatively small depth of artesian water in the area comprising the northern part of the town of Buraida and a narrow strip, some 3 kilometres across, to the north west. As stated previously the average depth in this « Shallow Zone» is only 150 meters. A short distance beyond this zone no artesian water was

produced from this depth, a sudden fall in the artesian water-table to 500 meters or even 750 meters being the rule instead (Fig. 3).

A supposition of subsurface faulting whereby the «Shallow Zone» could be explained as being located in the upthrown side of a fault cannot be substantiated from the general structural character of the country. No serious tectonic disturbances are in evidence in this part of Arabia, a simple homoclinal structure throughout Nejd being the rule. Yet a tectonic interpretation cannot be dismissed before a better knowledge of the subsurface structure is available.

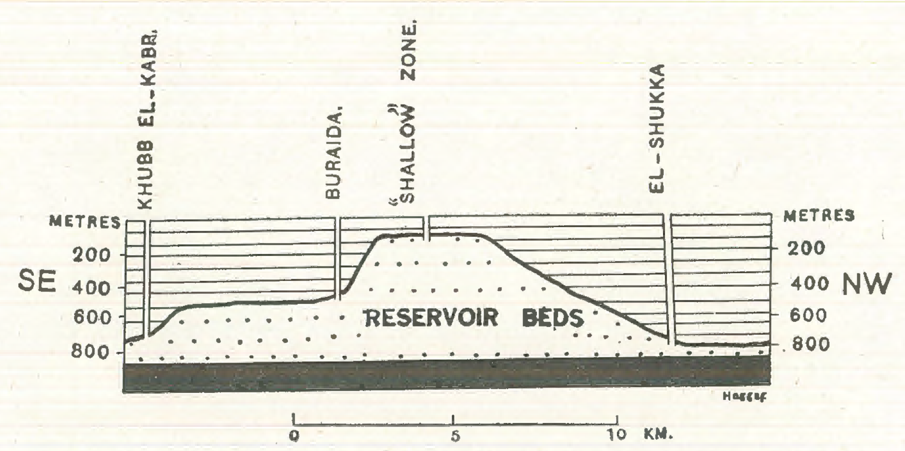


FIG. 3. — Origin of the «Shallow Zone» by postulation of a buried erosional surface.

An alternative explanation may, however, be formulated on the basis of morphological considerations. It is conceivable that the surface of the reservoir bed in Qassim had been deeply dissected by erosion before it was buried under the deposits of the Late Palaeozoic sea (Khuff Formation) and later deposits, through which the surface water has been conducted to its underground reservoir. Where the present surface is underlain by a hill or a plateau segment of this buried erosional surface underground water should be encountered at a smaller depth, while the deeper water-table should be linked with lowlands or depressions excavated in the same ancient surface. An illustration of this concept is shown in Fig. 3, an imaginary section in this buried land surface beneath the Buraida zone. Considerable erosion is evidently postulated, the surface attaining a mature stage of dissection with strong relief.

In support of this postulate it may be remarked that there is geological evidence of continental conditions and subaereal erosion throughout vast periods of the Palaeozoic Era. As mentioned before the Khuff Formation rests on the earliest formation of that era, i. e. the Saq Sandstone, in Al-Sirr Zone. Elsewhere in Arabia it rests on other Palaeozoic formations or on the basement [1]. In Northern Ethiopia, the Palaeozoic has witnessed vast subaereal erosion [2]. Topographical irregularities in the postulated buried surface could also be invited to explain at least some of the unsuccessful borings in Qassim. Local complete removal of the formation constituting that surface, i. e. the future reservoir formation, is conceivable at a certain stage of the erosional cycle and under certain conditions of the structure.

This is all very tentative, however. Solving problems of this nature in a satisfactory manner must perforce await the detailed study of subsurface conditions. It is hoped that, in such a study, geologists and hydrologists will give due attention to the ancient morphology of the country. In the buried relief rather than in the subsurface structure, may lie the key to solving the problems of both the vertical and areal distribution of the artesian water of Qassim.

ACKNOWLEDGMENT

My thanks are due to the University of Riyadh for kindly meeting the expenses of my trip to Qassim; to Sheikh I. Al-Rashid of Buraida for the many practical facilities he generously provided during part of the trip; and to Mr. S. Al-Rawaf of the Buraida Municipality and Mr. A. Al-Dihamy of Al-Badai'e, Uneiza, for the useful information they kindly offered.

(1) Max STEINKE and others, *op. cit.*, p. 1302.

(2) Y. ABUL-HAGGAG, *A Contribution to the Physiography of Northern Ethiopia*, The Athlone Press, University of London, 1961, pp. 16-17.

TEMPERATURE IN RELATION TO AIRCRAFT OPERATIONAL ENVIRONMENTS: AN EASTERN MEDITERRANEAN EXAMPLE

BY

THOMAS L. BRYANT

The areal delimitation of the Middle East has plagued geographers for many years [1]. A further complication in delimitation involving the vertical dimension arises in connection with aircraft operation in those parts of the world in which high air temperatures may be routinely expected. An example of such a « temperature region» is furnished by the summer conditions of the Eastern Mediterranean area. Here the elevations of airport surfaces and terrain obstacles effectively vary with air temperature for the calculation of aircraft performance data. Each air temperature situation furnishes a different operational density altitude environment for aviation operations. The purpose of this paper is to briefly examine some aspects of summer air temperature conditions in the Eastern Mediterranean area in relation to aircraft performance.

Aircraft performance, for standardization and convenience, is usually established in relation to dry-air « standard day» criteria represented by sea level conditions of 29.92 inches of mercury atmospheric pressure and a temperature of 59 degrees Fahrenheit (15 degrees Centigrade). A linear progression of the temperature lapse rate involving cooling at some 3.57 degrees Fahrenheit per thousand feet within the troposphere is also a feature of « standard conditions» for aircraft performance calculations [2].

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[1] W.B. Fisher, *The Middle East : A Physical, Social and Regional Geography*, 4th ed. (London : Methuen and Company Limited, 1961), 1-4.

[2] United States, Department of the Air Force, *Aircraft Performance Engineering* (Washington : Government Printing Office, 1954), 70.

The usually higher-than-standard daytime air temperatures associated with the Eastern Mediterranean region effectively increases the density altitude or the operational environment for aircraft operations. Assuming standard pressure, the aircraft density altitude environment of the Idris Airport, Tripoli, Libya, during the month of July (average daily temperature maximum of 98° F. [1]) is approximately 3,000 feet rather than 263 feet as published in aeronautical charts. Examples of density altitude conditions in the area of the summertime Eastern Mediterranean are contained in Table 1 on the page following.

Increases in density altitude adversely effect aircraft performance in many ways; « thinner» air causes lengthened takeoff distances, reduced rates of climb, higher true stalling speeds, decreases in propeller efficiency, losses in engine power, etc. The sea level takeoff ground roll of the Douglas DC-3 aircraft is lengthened approximately ten per cent at temperatures of 75° F. and twenty per cent at 100° F., for example. Aircraft power losses can also be approximated for purposes of illustration; performance engineers expect a 1.5 per cent power loss for each nine degree (Fahrenheit) temperature increase above « standard day» conditions [2].

The computation of aircraft performance in regard to effective operational environment is considered a critical area for analysis from the standpoint of flight safety and air transport economics. Aircraft presently utilized in Eastern Mediterranean air services can very easily be loaded to the point where they cannot be safely operated within existing operational environments. In order to achieve safe flight performance, airline operators may find it necessary to reduce aircraft payloads and sacrifice revenue or reduce fuel loads and sacrifice range. The problem is magnified in the Eastern Mediterranean area by mountainous terrain in close proximity to airports; these terrain obstacles may require an initial climb to a moderately high cruising altitude.

[1] Great Britain, Air Ministry, Meteorological Office, *Tables of Temperature, Relative Humidity and Precipitation for the World, Part IV, Africa, the Atlantic Ocean South of 35° N. and the Indian Ocean* (London : Her Majesty's Stationery Office, 1958), 93.

[2] United States, Department of the Air Force, *op. cit.,* 201-202.

Table 1

Density Altitude Operational Environments : Selected Eastern Mediterranean Stations

(Standard Pressure Conditions Assumed)

STATION	ELEVATION (Feet above Sea Level)	AVERAGE DAILY MAXIMUM : JULY (° Fahrenheit)	DENSITY ALTITUDE d (Feet above S.L.)
Benghazi, Libya	82 a	84 a	1,800
RAF Station El Adem, Libya	525 a	88 a	2,450
Alexandria, U.A.R.	105 a	85 a	1.800
Cairo, U.A.R.	381 a	96 a	2.900
Amman, Jordan	2,548 b	89 b	4,900
Damascus, Syria	2,362 b	96 b	5,100
Beirut, Lebanon	111 b	87 b	2,000
Nicosia, Cyprus	716 c	97 c	3,200
Adana, Turkey	82 b	93 b	2,300
Rhodes, Greece	289 c	83 c	1,650
Athens, Greece	351 c	90 c	2,400
Iraklion, Greece (Crete)	98 c	85 c	1,950

a) Great Britain, Air Ministry, Meteorological Office, *Tables of Temperature, Relative Humidity and Precipitation for the World, Part IV, Africa, the Atlantic Ocean South of 35° N. and the Indian Ocean* (London : Her Majesty's Stationery Office, 1958).

b) Great Britain, Air Ministry, Meteorological Office, *Tables of Temperature, Relative Humidity and Precipitation for the World, Part V, Asia* (London : Her Majesty's Stationery Office, 1958).

c) Great Britain, Air Ministry, Meteorological Office, *Tables of Temperature, Relative Humidity and Precipitation for the World, Part III, Europe and the Atlantic Ocean North of 35° N.* (London : Her Majesty's Stationery Office, 1958).

d) Computed from standard density altitude charts.

Flight safety considerations demand the computation of density altitude equivalents and aircraft performance from the standpoint of current meteorological conditions for each flight. Climatological techniques, however, may be effective in the economic correlation of air transport routes in regard to airport spacing, runway lengths and the aircraft equipment to be utilized. Climatological averages might also prove worthwhile in emphasizing to aircrews the vital importance of preflight performance calculations.

The possibilities of regional climatological analyses in terms of aircraft performance are practically limitless. A few examples involving the Eastern Mediterranean area may furnish direction to some of the techniques involved.

The «thin air» takeoff performance of the Convair 240, an aircraft utilized on Eastern Mediterranean routes, is contrasted with « standard day» performance in Table 2 below. It will be noted that the effect of increased altitude is quite pronounced in regard to the length of the ground run required to attain safe flying speed.

The effect of reduced air density is even more critical when an emergency situation requires engine shutdown during flight. For twin-engine aircraft, the computed single engine rate of climb immediately following takeoff should permit the safe avoidance of obstacles near the airport of departure. The minimum one-engine rate of climb generally accepted is 100 feet per minute when flat ground surrounds the flying facility. Table 3 indicates that this minimum acceptable single engine rate of climb is not possible at some Eastern Mediterranean stations for departing Convair 240 aircraft during high temperature conditions at « maximum-except-takeoff» power settings. (« Maximum-except-takeoff» power, abbreviated METO, is the highest power which can be sustained for periods greater than five minutes).

Performance restrictions caused by the shutdown of one engine must also be carefully considered for low and medium performance twin-engine aircraft scheduled to operate over mountainous terrain. Calculations might reveal that a safe obstacle clearance altitude could not be maintained with the power available from the one engine still in operation.

TABLE 2

A COMPARISON OF THE DEPARTURE PERFORMANCE OF THE CONVAIR 240 AIRCRAFT UNDER STANDARD AND HIGH AIR TEMPERATURE CONDITIONS : SELECTED EASTERN MEDITERRANEAN STATIONS.*

Computations are based on the use of Pratt and Whitney R-2800-97 engines operating at maximum power with water injection, carburetor air temperature 30° C., wing flap extension computed to provide a minimum of 100 feet per minute single engine rate of climb at maximum power, aircraft gross weight of 43,000 pounds, dewpoint 50° F., zero wind, hard surfaced runways of zero slope and standard pressure conditions.

STATION	DENSITY ALT. FIELD ELEV. (Std. Temp.)	WING FLAPS FOR TAKEOFF	APPROX. TAKEOFF DISTANCE (Feet)	HIGH DENSITY ALTITUDE ENVIRONMENT (Table 1 Temp.)	WING FLAPS FOR TAKEOFF	APPROX. TAKEOFF DISTANCE (Feet)
El Adem, Libya	525'	12°	3,250	2,450'	6°	3,750
Alexandria, U.A.R.	105'	12°	3,150	1,800'	12°	3,500
Cairo, U.A.R.	381'	12°	3,250	2.900'	6°	3,800
Amman, Jordan	2,548'	0	4,250	4,900'	0	4,750
Damascus, Syria	2,362'	0	4,200	5,100'	0	4,750
Nicosia, Cyprus	716'	12°	3,300	3,200'	6°	3,850
Iraklion, Greece	98'	12°	3,150	1,950'	6°	3,600

* Computed from the performance charts for the Convair 240 aircraft.

TABLE 3

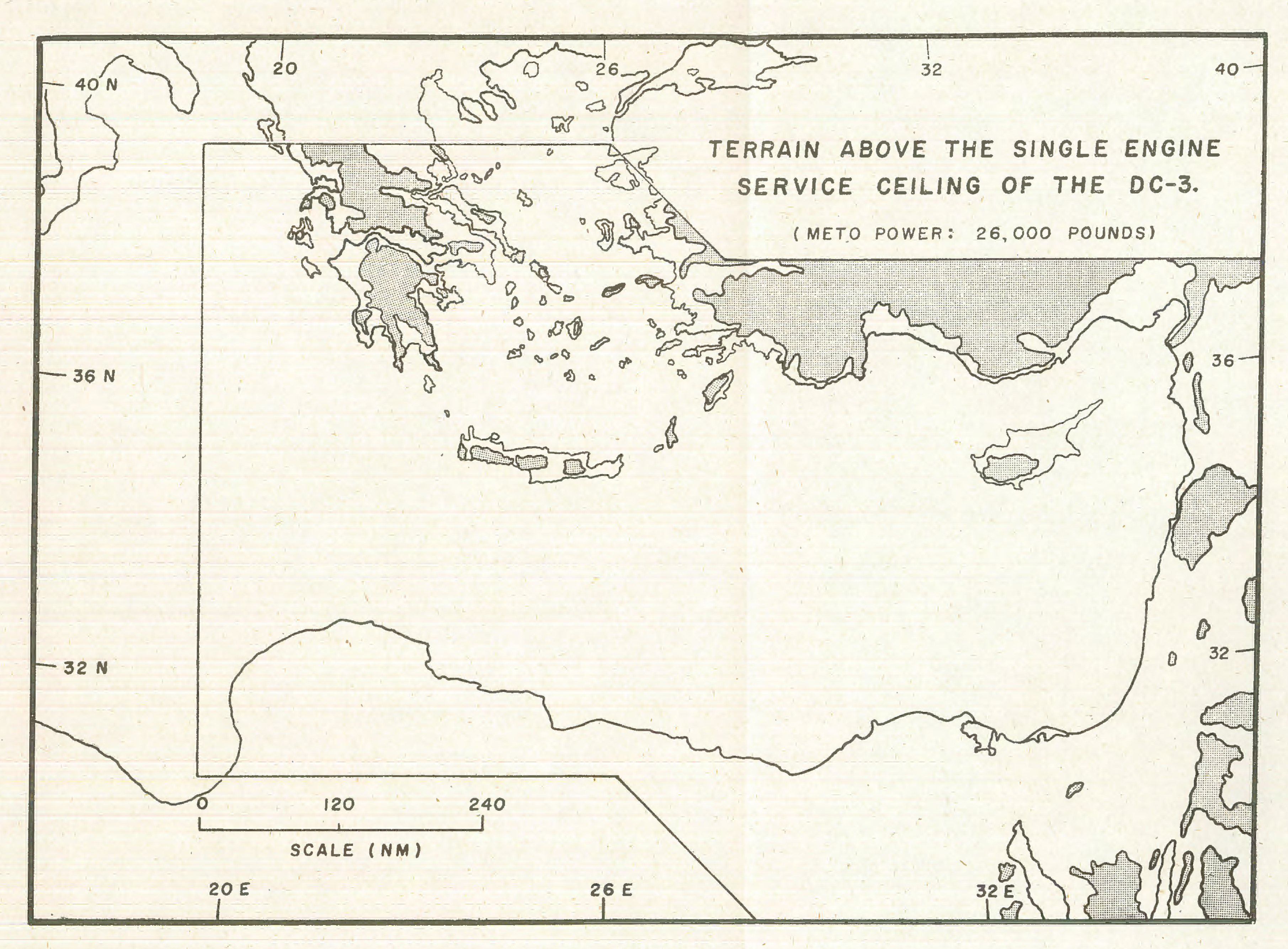
SINGLE ENGINE CLIMB PERFORMANCE OF THE CONVAIR 240 AIRCRAFT : SELECTED EASTERN MEDITERRANEAN STATIONS *

Computations are based on one Pratt and Whitney R-2800-97 engine operating at 105 p.s.i. torque pressure without water injection, aircraft gross weight 42,000 pounds, inoperative propeller feathered, landing gear and wing flaps retracted and standard pressure conditions.

STATION	APPROXIMATE RATE OF CLIMB (Standard Temperature Conditions)	APPROXIMATE RATE OF CLIMB	DENSITY ALTITUDE (Table 1 Temp.)
Benghazi	140 feet/min.	110 feet/min.	1,800'
Cairo	130 feet/min.	90 feet/min.	2,900'
Amman	100 feet/min.	50 feet/min.	4,900'
Damascus	100 feet/min.	40 feet/min.	5,100'
Nicosia.	115 feet/min.	85 feet/min.	3,200'

The shaded area depicted on Figure 1 locates terrain which is higher than the single engine capability of the Douglas DC-3, another aircraft in use in the Middle East. The performance of this aircraft was studied at the nominal gross weight of 26,000 pounds which is slightly higher than the allowable operational weight of DC-3's in regular airline service but well below the maximum for military operations. The term « single engine service ceiling» is defined as the maximum altitude at which a 100 foot per minute rate of climb could be maintained with one engine operating at METO power. The map comprising Figure 1 is based on the *average* highest temperatures of June, July and August as recorded at fourteen selected Eastern Mediterranean stations; it also

* Computed from the performance charts for the Convair 240 aircraft.



TERRAIN ABOVE THE SINGLE ENGINE SERVICE CEILING OF THE DC-3.
(METO POWER: 26,000 POUNDS)
40 N
36 N
32 N
20
26
32
40
36
32
0
120
240
SCALE (NM)
20 E
26 E
32 E

Fig. 1.

assumes the existence of a standard temperature lapse rate. Standard aircraft performance charts indicated that the single engine service ceiling of the DC-3 ranged from approximately 3,800 feet in the northern sector of the Eastern Mediterranean to 2.800 feet in the southern sector.

These few examples will serve, it is hoped, to point out the desirability of climatological studies of aircraft performance. Many factors of high density altitude environments have not been considered; the dramatic effect of high air temperatures in relation to jet aircraft performance has not been mentioned and conditions of high specific humidities has also been omitted. These omissions, and many others, strongly suggest the necessity for an applied geography of aviation.

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L'ALUN ÉGYPTIEN

INTRODUCTION HISTORIQUE

PAR

LOUIS-A. CHRISTOPHE

L'Egypte, « don du Nil», est une image historique dont il ne faudrait pas abuser. Certes, durant des siècles, le pays a été soumis à sa vocation agricole, mais l'évolution des techniques, plus encore que les contingences politiques, a considérablement modifié son économie générale. Au siècle dernier, la décadence de l'empire turc a coïncidé avec l'apparition des bateaux à vapeur : le développement de l'industrie en Europe a progressivement accéléré le transport des matières premières. Aussi, avec le creusement du canal de Suez, l'Egypte est-elle bien vite devenue une puissance commerciale de premier plan grâce à sa position privilégiée, au carrefour des grandes routes africaines, asiatiques et européennes.

Au xxe siècle, la croissance démographique a imposé aux dirigeants de l'Egypte la recherche de voies nouvelles. L'extension des terres cultivées ou la promotion du Caire au rang de plaque tournante pour la navigation aérienne en Méditerranée orientale ne résolvaient qu'une fraction des difficultés. Il ne restait plus qu'une solution, celle qui a d'ailleurs été adoptée, l'industrialisation aussi poussée que possible. La médiocrité des ressources en combustibles pouvait être compensée par la force motrice électrique. La politique gouvernementale s'attacha alors à la formation technique d'une classe ouvrière, aussi nombreuse que bien entraînée. Et, à côté des industries traditionnelles, fondées surtout sur les matières premières agricoles : coton, canne à sucre, céréales, oignons, fruits, se créèrent de nouveaux complexes : usines d'engrais, métallurgie, etc.

Ces nouvelles industries utilisent les ressources du sous-sol égyptien, ressources dont l'inventaire est dû à des équipes de savants qui, durant les dernières décennies, ont parcouru les déserts — montagnes et

plateaux — limitant la vallée du Nil, établi la carte géologique détaillée de ce vaste territoire, prélevé et analysé des spécimens de roches, délimité les gisements et évalué les réserves. Cette reconnaissance des richesses minières de l'Egypte est aujourd'hui à peu près terminée; ce premier pas, essentiel pour une utilisation rationnelle des produits du sous-sol, devait normalement ouvrir de nouveaux horizons à l'économie d'un pays en pleine expansion. Aussi les résultats qui ont déjà été obtenus, par l'application récente d'une planification raisonnée et raisonnable, permettent-ils d'espérer d'autres réalisations industrielles malgré certains obstacles difficiles à surmonter : les minéraux décelés sont peu variés; ils sont en quantité relativement faible; les gisements sont souvent éloignés des centres urbains où les usines doivent nécessairement être implantées.

Toutefois cet effort moderne de mettre rationnellement à profit les produits du sous-sol égyptien ne doit pas faire oublier l'exploitation antérieure des ressources minières de l'Egypte. Laissant de côté les carrières de calcaire, de grès, de granit ou d'albâtre, les mines d'or, de malachite, de turquoise ou d'améthyste, et quelques autres exploitations minérales de moindre importance, penchons-nous vers l'un des produits qui était déjà connu, extrait et utilisé à l'époque pharaonique, l'alun.

* * *

L'historien n'est ni géologue, ni chimiste. Il lui faut donc recourir au dictionnaire pour définir certains termes scientifiques ou techniques et croire le *Larousse* lorsqu'il décrit l'alun comme « un sulfate double d'aluminium et de potassium, qui a une saveur astringente et sert à fixer les teintures sur les étoffes, à clarifier les eaux et à conserver les peaux et les clichés photographiques».

On verra que cette définition, malgré sa concision et sa rigueur, est parfaitement illustrée par les notes historiques qui vont suivre.

* * *

L'alun égyptien ne se rencontre que dans trois oasis du désert occidental : à *Dakhla,* où il y a plusieurs gisements, mais tous sont de faible

importance [1]; à *Kharga,* où il est en plus grande quantité et plus facilement exploitable [2]; enfin, loin vers le sud, près de la frontière soudanaise, dans la petite oasis d'*El-Chab,* la bien nommée puisqu'elle porte le nom de l'alun lui-même, en arabe شبة *Chabba* [3].

Ainsi l'alun se trouve au fond de grandes dépressions dans des couches d'argile finement feuilletées où il voisine généralement avec des gisements de sel et de gypse [4].

* * *

L'exploitation industrielle de l'alun remonte à la plus haute antiquité, mais nous n'avons pu recueillir que deux chiffres. Au XIIIe siècle de notre ère, sous les Ayyoubides, on en extrayait annuellement mille qantars, soit environ 45 tonnes [5]. Cette production dépassait 200 tonnes au début du XXe siècle [6]. Il est difficile de dire si, aux différentes époques, les besoins de l'Egypte en alun étaient couverts. En effet, pour la même période, la première moitié du XIXe siècle, les informations diffèrent : un auteur estime que la production de l'alun était suffisante pour

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(1) H.J.L. Beadnell, *Dakhla Oasis : its topography and geology,* p. 100-101; A. Lucas, *Ancient Egyptian Materials and Industries,* 3e édition, 1948, p. 291-293. Rushdi Saïd, *The Geology of Egypt,* p. 273.

(2) John Ball, *Kharga Oasis : its topography and geology,* p. 83 et suiv.; H.J.L. Beadnell, *An Egyptian Oasis* (Khargeh), p. 21, 125 et 220-223; A. Lucas, *op. cit.,* p. 291-293; G. Caton-Thompson and E.W. Gardner, *The Prehistoric Geography of Kharga Oasis,* dans *The Geographical Journal,* LXXX, 1932, p. 372; Marchal et Berlan, *Le Bassin du Nil,* p. 194, où il est mentionné que Kharga produit aussi du sulfate de magnésie. C'est ce qu'indique aussi Rushdi Saïd, *op. cit.*, p. 273.

(3) J.L. Burckhardt, *Travels in Nubia,* p. 31; Frédéric Cailliaud, *Voyage à Méroé et au Fleuve Blanc,* t. III, p. 246; Félix Mengin, *Histoire de l'Egypte sous le gouvernement de Mohammed-Aly,* t. II, p. 230 et 422. — Cette petite oasis se trouve à la latitude d'Abou Simbel, mais à près de cent quatre vingts kilomètres du Nil.

(4) *Bulletin de l'Institut Egyptien,* 1re série, n° 13, 1875, p. 79 : le Dr Zittel a découvert à Kharga des «marnes feuilletées vertes, quelquefois alunifères»; John Ball, *op. cit.,* p. 84.

(5) Maqrîzî, *Description topographique et historique de l'Egypte,* dans *Mémoires de la Mission archéologique française au Caire,* t. XVII, p. 698.

(6) A. Lucas, *op. cit.,* p. 292.

permettre une exportation [1]; un autre indique qu'on en faisait venir d'Angleterre [2].

* * *

L'alun était très certainement connu des anciens Egyptiens, mais un doute persiste sur le nom qui lui était donné, le même mot pouvant aussi bien désigner l'alun que le natron [3]. Avant le Nouvel Empire l'alun était probablement confondu avec d'autres produits appelés *bd*, *ḥsmn*, *bsn*, [4] *ỉmrw* ou encore *ỉnr n šn* [5]; mais on peut considérer comme établi qu'au temps du grand Empire égyptien, sous les Thoutmosides ou les Ramessides, l'alun était différencié et identifié par un mot emprunté sans doute aux langues asiatiques : *ỉbnw* [6].

Cet *ỉbnw* était employé en médecine [7]; on l'utilisait aussi dans des préparations magiques [8]. Et si Ramsès III (XXe dynastie) en distribua trois couffins aux temples mineurs de l'Egypte [9], c'est probablement qu'il servait aussi pour la teinture des étoffes sacrées.

Un peu plus tard, sous la XXVIe dynastie (VIe siècle av. J.-C.), les mines d'alun étaient certainement en pleine activité puisque le roi Amasis fit, au temple de Delphes, cadeau d'une grande quantité de ce minéral, pour une valeur de mille talents, et que les Grecs habitant l'Egypte en envoyèrent aussi pour vingt mines [10].

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(1) Clot-Bey, *Aperçu général sur l'Egypte,* t. I, p. 147.

(2) F. Mengin, *op. cit.,* t. II, p. 411.

(3) Aucune information utilisable dans Brugsch, *Sur les données fournies par les inscriptions hiéroglyphiques au sujet des Oasis,* dans *Bulletin de l'Institut Egyptien,* 1re série, n° 13, 1875, p. 96.

(4) J.R. Harris, *Lexicographical Studies on ancient Egyptian Minerals,* Berlin, 1961, p. 193.

(5) J.R. Harris, *op. cit.,* p. 187-188.

(6) J.R. Harris, *op. cit.,* p. 185-187. — Nom copte de l'alun : ⲱⲃⲉⲛ.

(7) *Papyrus Ebers* 63, 10; *Papyrus médical de Berlin* 4, 5 et 5, 3.

(8) François Lexa, *La magie dans l'Egypte antique,* t. II, p. 136 (cf. Griffith and Thompson, *The demotic magical Papyrus of London and Leiden,* t. I, II, III, § 3/5-3/35, 11°.

(9) *Papyrus Harris* 64 *c,* 5 = 73, 16.

(10) Herodote, II, 180.

Nous avons plus de renseignements sur l'exploitation de l'alun à l'époque romaine. Pline l'Ancien vante l'alun d'Egypte [1] et Dioscoride en parle aussi [2]. Un document égyptien, de l'an 145 ap. J.-C., nous donne son nom grec *στυπτηρία;* et ce document laisse entendre que, comme tous les minéraux extraits en Egypte, l'alun était alors propriété impériale, survivance probable du monopole royal du temps des Lagides. Ce monopole d'Etat impliquait un contrôle très sévère aussi bien dans les régions où on le produisait que dans celles où il était transporté. Enfin l'alun qui est mentionné dans ce papyrus provient de la Petite Oasis (Dakhla); mais la Grande Oasis (Kharga), où les vestiges gréco-romains sont si nombreux, était très peuplée et très prospère à cette époque et toutes ses richesses, y compris l'alun, devaient être largement exploitées [3]. L'alun est encore cité dans trois autres papyri [4]; toutefois ces documents n'apportent aucune information nouvelle.

* * *

L'extraction de l'alun se poursuivit normalement dans les Oasis après la conquête arabe, sans cesser d'être un monopole d'Etat [5]. Citons par exemple les paragraphes consacrés aux oasis par le grand Makrizi (1364-1442) :

« C'est une terre abondante en alun, en vitriol, en sources acides dont l'eau s'emploie comme le vinaigre, en sources dont le goût présente à la fois une saveur acide, astringente et salée» [6] ...... « Là

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(1) *Histoire naturelle,* XXXV, 52.

(2) *Matière médicale,* V, 123.

(3) Cf. Claire Préaux, *L'économie royale des Lagides,* p. 253. — A Kharga, l'exploitation de l'alun à l'époque romaine est attestée par des tessons (sherds) retrouvés dans les mines (G. Caton-Thompson and E.W. Gardner, *The Prehistoric Geography of Kharga Oasis,* dans *The Geographic Journal,* LXXX, 1932, p. 372).

(4) A.S. Hunt, *The Oxyrhynchus Papyri,* XVII, n° 2116; B.P. Grenfell and A.S. Hunt, *The Oxyrhynchus Papyri,* t. II, XII, n° 1429 et p. 134-136.

(5) D'après une source arabe, les recettes des mines d'alun formaient une partie du revenu de l'Etat (Stanley Lane-Poole, *A History of Egypt in the Middle Ages,* p. 304).

(6) Maqrîzî, *Description topographique et historique de l'Egypte,* dans *Mémoires de la Mission archéologique française au Caire,* t. XVII, p. 691.

se trouve une terre saturée d'alun et une autre saturée de vitriol, de sources acides et d'autres potables» [1] ...... « Aux Oasis, l'alun blanc se trouve dans une vallée qui fait face à la ville d'Edfou. Au temps d'El Melek El Kamel Mohammed ben El Adel Abou Bekr, et de son fils El Saleh Negm el din Ayyoub, on apportait chaque année des carrières des Oasis au Caire mille qantars d'alun blanc; en échange, on exonérait les habitants de l'impôt pour les terres des Oasis; puis cette coutume fut de moins en moins observée et cessa complètement» [2].

Il est facile d'imaginer que les difficultés financières des maîtres de l'Egypte aboutirent à la disparition des exemptions fiscales. Toutefois les besoins en alun maintinrent en activité l'exploitation des mines et le transport de la matière vers le Caire où la teinture des étoffes et la préparation des cuirs en faisaient une importante consommation. Et les préparations médicales en exigeaient aussi : il entrait en effet dans une recette contre les affections de la peau [3] et on l'employait probablement aussi pour la préparation des collyres secs [4]. Il est mentionné en ces termes par le cordouan Maïmonide (1135-1204) qui vécut près de quarante années en Egypte :

« CHABB. — *On l'appelle aussi le « vitriol blanc» et l'« alun humide du Yémen».*

L'alun « ad-dawr» est l'alun d'Egypte [5].»

Le commentateur de Maïmonide, Meyerhof, note que l'alun du Yémen était très réputé chez les Arabes et que le nom de l'alun d'Egypte s'explique peut-être par le fait qu'il s'y trouve en forme de masses arrondies [6].

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(1) MAQRÎZÎ, *op. cit.*, p. 697.

(2) MAQRÎZÎ, *op. cit.*, p. 698. — El Malek El Kamel Mohammed ben El Adel Abou Bakr, souverain ayyoubide, règna de 1218 à 1238. Son second fils, El Saleh Negm el din Ayyoub, époux de Chagarret el Dorr, gouverna l'Egypte de 1240 à 1249.

(3) Max MEYERHOF, *Un glossaire de matière médicale composé par Maïmonide,* Mémoires de l'Institut d'Egypte, t. XLI, p. 160, § 321.

(4) MEYERHOF, *op. cit.*, p. 184.

(5) MEYERHOF, *op. cit.*, p. 184, § 368.

(6) MEYERHOF, *op. cit.*, p. 184-185.

* * *

Nos informations sur l'exploitation de l'alun à Kharga ou Dakhla durant l'époque mamelouke sont pratiquement nulles. En revanche, nous savons que celui de l'oasis d'El-Chab arrivait jusqu'au Caire.

« Nombre d'entre eux [les Bédouins de la tribu des Kerrarish] vont de Ouadi-Halfa, sur le Nil, dans le désert occidental, à trois journées de marche, pour y ramasser le Chabb ou nitre [alun] qu'ils échangent avec les mêmes marchands [ceux d'Esna] contre du maïs, donnant deux mesures de Chabb contre trois mesures égales de maïs. On trouve ce nitre en creusant seulement à quelques pouces de profondeur; il couvre une étendue de plusieurs milles. C'est toutefois un trafic périlleux parce que les habitants de Koubanieh, un village situé à une douzaine de milles au nord d'Assouan, le font aussi; ceux-ci ont onze jours de marche avant d'atteindre les puits de nitre et toutes les fois que les deux groupes se rencontrent, un conflit sanglant surgit [1].»

Telle était la situation en Nubie avant 1813. Le texte de Burckhardt appelle néanmoins un commentaire. L'alun de l'oasis d'El-Chab était-il donc si prisé en Egypte et si nécessaire? Il le fallait bien puisque les habitants d'un village situé à une vingtaine de kilomètres au nord d'Assouan n'hésitaient pas, pour un profit certainement substantiel, à entreprendre avec les bêtes de somme indispensables, des chameaux, un voyage de onze jours dans le désert occidental [2].

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(1) J.L. BURCKHARDT, *Travels in Nubia,* p. 31.

(2) Les derniers renseignements donnés par Burckhardt se trouvent déjà dans W. HAMILTON, *Remarks on several parts of Turkey — Part I — Aegyptiaca,* p. 428. — Hamilton, qui vint en Egypte en 1801-1802, précise que la caravane de Koubanieh est annuelle et qu'elle comprend cinquante chameaux. Ses informateurs lui ont dit que les mines d'alun se trouvaient dans une dépression au sud-ouest de la première cataracte, à dix ou onze jours de marche. Ces mines consistaient en une seule couche de deux à quinze pouces d'épaisseur, couverte par un demi-pied environ de sable sec et reposant sur un lit de sable humide. L'alun, avant son transport, était cassé en morceaux et séché au soleil. — Cf. aussi P.S. GIRARD, *Mémoire sur l'agriculture, l'industrie et le commerce de l'Egypte,* dans *Description de l'Egypte,* 1re édition, Etat moderne, t. II, p. 623.

Une augmentation de la consommation de l'alun au Caire, à cette époque, ne peut être envisagée. Il faut alors admettre que les mines de Kharga avaient pratiquement cessé d'être exploitées ou que leur production était insuffisante. Cette insuffisance pourrait s'expliquer par de mauvaises relations commerciales entre Kharga et Assiout. Pourtant la caravane qui venait du Darfour par la route désertique (*Darb el Arbayn*) et traversait, avant d'atteindre Assiout, aussi bien l'oasis d'El-Chab que celle de Kharga, continuait normalement son trafic. Il faut donc envisager une autre hypothèse : celle de l'incurie administrative des beys établis à Kharga qui pressuraient la population et entravaient le développement économique de l'oasis.

En effet, il s'agirait bien d'un arrêt de l'exploitation de l'alun dans l'oasis de Kharga et cet abandon des mines paraît être confirmé par un texte de Frédéric Cailliaud [1].

« A trois jours plus au sud [lire *nord*], elle [la caravane] séjourne encore à Chab (dont le nom signifie *Alun*), lieu où l'on trouve quelques végétaux ; son territoire fournit une terre alumineuse rougeâtre, dont il se fait en Egypte un bon débit. A cinq jours de là, la caravane s'arrête à Bérys [Baris, la source la plus méridionale de l'oasis de Kharga], village dépendant de l'oasis de Khargeh, où elle trouve beaucoup de ressources ; et après avoir passé à Boulak, autre village de la même oasis, elle arrive au bout de deux jours à Khargeh, qui en est le chef-lieu.»

Notons qu'en 1818, le minéralogiste Frédéric Cailliaud, accompagnant l'ancien consul de France à Alexandrie, Bernardin Drovetti, avait découvert le temple de Kharga et fait une longue prospection dans l'oasis. Quand il entreprit son voyage au Soudan en 1820, il était donc parfaitement

[1] Frédéric Cailliaud, *Voyage à Méroé et au Fleuve Blanc...*, t. III, p. 246. — Selon Cailliaud, voici les étapes des caravanes entre le Darfour et Assiout : de la capitale du Darfour, Cobbé, au lieu de réunion de tous les chameliers, Soueïny, 5 jours de voyage ; de Soueïny à Madaoua, 3 jours ; de Madaoua à Bir el Malh, 8 jours ; de Bir el Malh à El-Eguy, 4 jours ; d'El-Eguy à l'oasis de Selimeh, 4 jours ; de l'oasis de Selimeh à celle d'El-Chab, 3 jours ; d'El-Chab à Baris, 5 jours ; de Baris au village de Kharga, 2 jours ; et de Kharga à Assiout 6 ou 7 jours. Ce qui donne 40-41 jours de voyage dans le désert et justifie l'expression de *Darb el Arbayn* (piste des quarante [jours]).

au courant des productions de Kharga ; et si l'alun avait été à ce moment-là l'une des ressources essentielles de l'oasis, il y aurait très certainement fait allusion lorsqu'il mentionne l'importance pour l'Egypte de l'alun d'El-Chab.

* * *

La remise en exploitation des mines d'alun de Kharga et, peut-être aussi, de Dakhla, plus proches du Caire que celles d'El-Chab, paraît coïncider avec le séjour de Félix d'Arcet en Egypte dans les années 1828 et 1829. En effet, ce savant, issu lui-même de plusieurs générations de scientifiques, introduisit le procédé de la clarification de l'eau du Nil par l'alun [1]. A la même époque, plusieurs industries nouvelles se créèrent autour du Caire et dans le Delta ; citons, parmi elles, des usines de tissage du coton (développement de cette culture dû à Jumel), des fabriques de tarbouches (la plus fameuse était celle de Fouah) et des tanneries [2]. Aux tanneries traditionnellement installées à Assiout, au débouché de la piste qui vient de Kharga, s'ajoutèrent notamment celles de Rosette. Ces différentes industries avaient toutes le plus grand besoin d'alun.

* * *

Le développement économique de l'Egypte aux alentours de 1830 nous est connu par un ouvrage précieux, celui de Clot-Bey. On y lit notamment [3] : « M. Haim, chimiste français, a formé plusieurs établissements importants pour la fabrication des produits chimiques des manufactures, et principalement de l'acide sulfurique. Il a sous sa direction plusieurs salpêtrières, où, comme je l'ai dit [4], on obtient le salpêtre par le moyen de l'évaporation. Les fabriques de ce genre sont au nombre

[1] Jean-Jacques Ampère, dans *Revue des Deux Mondes*, t. XIX, 1847, p. 211, note 2.

[2] Clot-Bey, *Aperçu général sur l'Egypte*, t. II, p. 273 et 289-290 ; Moustafa Fahmy, *La révolution de l'industrie en Egypte et ses conséquences sociales au 19e siècle* (1800-1850), p. 22-23 et 45-46.

[3] Clot-Bey, *Aperçu général sur l'Egypte*, t. II, p. 276-277.

[4] Clot-Bey, *op. cit.*, t. I, p. 146.

de six». Ces fabriques formaient trois groupes : celui du Caire et de sa banlieue (Badrachein); celui de Moyenne-Egypte (Achmounein, Ahnas et le Fayoum), enfin le petit centre de Terraneh, dans le Delta occidental [1].

* * *

Ce M. Haim est un personnage curieux, que nombre de voyageurs ont rencontré entre 1829 et 1853. Et il est impossible de traiter de l'exploitation de l'alun égyptien dans la première moitié du XIXe siècle sans en faire mention. Que les auteurs écrivent son nom Haim, Aim, Em, Aym, Aymi ou Haymes, il s'agit toujours du même chimiste, s'occupant dans la même région de la même industrie et s'appelant réellement, semble-t-il, Aymes, plus tard Aymes-Bey.

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La première à l'avoir vu est la Contemporaine, cette ancienne courtisane d'origine hollandaise qui fut attachée à la police secrète de Napoléon Ier et qui, devenue médiocre femme de lettres, abandonna son nom d'Elzélina Van Aylde Jongue pour le pseudonyme d'Ida de Sainte-Elme. C'était en 1829 et Aymes devait alors habiter le Caire ou sa banlieue immédiate et faire de fréquents voyages à Alexandrie. Si la Contemporaine juge (mais quel mauvais juge !) très défavorablement la moralité de M. Aim, elle loue indirectement sa générosité; mais elle nous dit peu de chose sur son activité : pour elle, il est simplement « attaché au service du vice-roi» [2].

* * *

En 1830, la situation d'Aymes paraît plus assise. Cadalvène et Breuvery, comme Clot-bey, reconnaissent qu'il occupe un poste important : « La fabrique de produits chimiques, confiée à un Français, M. Haymes,

[1] Mêmes renseignements dans Moustafa FAHMY, *La révolution de l'industrie en Egypte*...., p. 47-48; cf. aussi p. 39.

[2] *La Contemporaine en Egypte*..., t. I, p. 323-325, 338 et t. II, p. 6-7 et 49.

a eu plus de succès, et fournit aux diverses manufactures du vice-roi les substances dont elles ont besoin pour la teinture» [1].

A l'automne de 1834, Aymes est toujours au Caire, à la tête de l'industrie chimique égyptienne. C'est alors qu'il rencontre l'un de ses anciens chefs, le maréchal Marmont, duc de Raguse [2] : « Je retrouvai au Caire un homme que je connaissais depuis longtemps, M. Haim, chimiste français, anciennement employé sous mes ordres à l'armée de Portugal. Il a formé, pour la fabrication des produits chimiques nécessaires aux manufactures, et principalement de l'acide sulfurique, des établissements qui prospèrent [3]. Il a aussi des salpêtrières dans lesquelles l'évaporation se fait en plein air, par l'action du soleil. Elles donnent, à très bon prix, une quantité de nitrate de potasse fort supérieure aux besoins [4].

« M. Haim est associé de Méhémet-Ali. Ses opinions politiques sont prononcées, et il passe pour républicain. On raconte que sa réputation étant venue aux oreilles du pacha, celui-ci lui demanda de lui expliquer ce que c'était qu'une république. M. Haim lui en donna la définition en deux mots : Si l'Egypte était une république, lui dit-il, vous seriez le peuple, et le peuple serait le pacha». Méhémet lui répondit qu'il ne se trouvait aucun goût, aucune sympathie pour une république.»

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Mais Aymes se spécialise bientôt dans l'exploitation des mines d'alun. Hector Horeau, dont le voyage en Egypte date de 1837, est le premier à nous en informer : « C'est près de Manfalout et dans la grande oasis de Thèbes [Kharga] que M. Aymes, chimiste français, qui exploite des

[1] Ed. de CADALVENE et J. de BREUVERY, *L'Egypte et la Nubie*, t. I, p. 131-132.

[2] *Voyage de M. le maréchal, duc de Raguse*, 4e édition, Paris, 1837, t. III, p. 301-302.

[3] Le maréchal Marmont nous apprend (t. III, p. 259) qu'au moment de son voyage en Egypte la salpêtrière de Terraneh est dirigée par Baffi (Omar bey).

[4] Ce passage de l'ouvrage du maréchal Marmont est directement inspiré du texte de Clot-Bey (cf. notre article p. 83).

mines d'alun, a trouvé des puits artésiens naturels d'où l'on voit, parfois, s'échapper des poissons»[1].

Deux ans plus tard, en 1839, Eusèbe de Salle a entendu la même histoire et donne des détails complémentaires : « Un chimiste français, Aymes-Bey, qui exploite dans cette oasis [la grande Oasis de Thèbes] des mines d'alun, a fait une découverte fort curieuse : de véritables puits artésiens arrosent le pays d'une eau très abondante et qui rejette parfois des poissons, particulièrement des *boulty*, semblables à ceux du Nil ...... Toutes ces oasis [depuis El-Chab] ont des puits artésiens qui paraissent de fabrique très antique. M. Aymes croit qu'une portion des eaux du Nil blanc se perd et alimente cette longue artère souterraine. Les poissons expulsés donnent quelque vraisemblance à l'hypothèse»[2].

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Mais il faut attendre 1842 pour être mieux renseigné sur Aymes. Le 30 janvier de cette année-là, Aymes dîna, en effet, chez Soliman-Pacha en compagnie du colonel du génie, Gallice, qui venait de fortifier Alexandrie, et d'un voyageur français, le comte de Saint-Ferriol. Et, dans son journal, le comte note : « M. Aymes, chimiste, républicain, bey des oasis, contant bien, mais n'ayant qu'un répertoire borné. Voilà son histoire qui est des plus singulières : il était venu en Egypte comme industriel; il établit dans les oasis une fabrique d'alun qu'il exploitait de compte à demi avec le Pacha. Au bout de deux ou trois ans, la fabrique allait assez bien et, comme elle employait constamment plus de 200 ouvriers, qu'il les payait et les traitait bien, il avait acquis une belle influence. Dix ou douze familles turques ou plus se partageaient l'autorité dont elles usaient fort despotiquement. Un beau jour, les Turcs lui disent qu'ils vont faire donner la bastonnade à une jeune fille, que ce sera drôle et qu'ils l'engagent à y assister pour se distraire un moment. Il le leur promet, mais il arme tous les ouvriers de bâtons, leur dit de se tenir prêts à le défendre à un signal convenu et il se rend sur la place

(1) Hector Horeau, *Panorama d'Egypte et de Nubie,* p. 11, verso.
(2) Eusèbe de Salle, *Pérégrinations en Orient,* t. II, p. 155-156.

où la victime attendait son supplice. Dès que M. Aymes paraît, les Turcs lui disent qu'on va commencer, mais il leur répond qu'on ne touchera pas cette jeune fille. — Pourquoi? — Parce que je ne le souffrirai pas — et il porte la main à la tête. A ce signal convenu, nos 200 bédouins tombent à bras raccourci sur les Turcs, les assomment et toute la population qui les détestait, ne tarde pas à se joindre aux révoltés. M. Aymes empêche qu'on ne tue les Turcs et les fait mener à deux jours dans le désert où on les laisse. Les Turcs vont naturellement se plaindre à Méhémet-Ali, mais les députés de M. Aymes lui exposent aussi les choses à leur manière. Finalement le pacha charge M. Aymes de faire rentrer les impôts et plus tard le nomme bey. Enfin il continue à le traiter parfaitement, mais il ne lui a jamais soufflé mot de son expédition. Maintenant il est le vrai roi du désert»[1].

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Il est probable que, malgré son grand'âge, Aymes-Bey continua, au moins jusqu'à la fin du règne de Mohammed-Ali, à exploiter les mines d'alun de Kharga. A l'avènement d'Abbas Ier, il fut contraint de ralentir, sinon de cesser son activité et il se retira à Assiout. C'est là que Flaubert le rencontra le 7 juin 1850[2] : « Le lendemain, déjeuner et sieste chez Cuny[3] ...... Visite à Aymi-Bey, dans sa belle maison sur le bord de l'eau. Intérieur sale; nous tournons dans deux ou trois petites cours où des chevaux aux entraves hennissent. — Aymi-Bey, vieillard sec, ardent, patriote, ennemi des prêtres, qu'il regarde comme des comédiens, vieux républicain de 93, s'indigne de la bassesse et de la tyrannie, balle[4] plaisante et énergique».

Cette image d'Aymes-Bey devait poursuivre longtemps l'auteur de *Madame Bovary* et de *Salammbô*. Onze ans plus tard, le 29 mars 1862,

(1) Texte du Journal du comte de Saint-Ferriol, dans Jean-Marie Carré, *Voyageurs et écrivains français en Egypte,* t. I, édition de 1932, p. 323-324; édition de 1956, p. 353-354.
(2) Gustave Flaubert, *Voyage en Orient* (édition du Centenaire, Paris, 1925), p. 124.
(3) Gendre de Linant de Bellefonds.
(4) Tête ou figure.

il faisait part de ses projets aux frères Goncourt : il rêvait d'écrire un ouvrage sur le monde oriental moderne. Et dans leur journal, les Goncourt s'empressèrent de consigner l'évocation, qui venait d'être faite devant eux, de « ce chimiste français qui, établi sur les confins de la Libye, n'a plus rien gardé des mœurs et des habitudes de sa patrie» [1].

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* *

La maison d'Aymes est exactement localisée par un voyageur de 1851, le botaniste Henry Husson [2]; elle s'élevait au sud de l'agglomération d'Assiout, dans le village d'El-Hamra. « 7 mars 1851. — Nous étions juste en face de la maison de Aym Bey, la plus considérable d'El Hamra, mais m'étant informé de lui, j'appris qu'il était à quelque distance dans les campagnes de l'intérieur».

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* *

La dernière mention d'Aymes nous donne la date approximative de sa mort. Charles Didier le rencontra au Caire en 1853 et il nous apprend qu'il est mort, dans le livre qu'il publia en 1854.

Charles Didier était friand d'historiettes qu'il recueillait aussi bien chez ses hôtes que dans les ouvrages qu'il dépouillait et démarquait effrontément [3]. Son portrait d'Aymes, plus complet que celui des auteurs précédents, est néanmoins à peu près certainement authentique. Le voici. « Il se trouve à l'ouest de Siout un certain nombre d'oasis dont quelques-unes étaient exploitées par un Français à qui Méhémet-Ali les avait concédées, et qu'on appelait pour cette raison le Roi des Oasis. Or ce roi, alors plus qu'octogénaire, était un terroriste pur sang, un ancien ami de Robespierre, ce qui ne l'avait pas empêché

[1] *Journal des Goncourt,* 1re série, vol. II, p. 23. Cité par Jean-Marie Carré, *op. cit.,* t. II, édition de 1932, p. 122 et note 2; édition de 1956, p. 128 et note 1.

[2] Il s'agit d'un manuscrit anonyme acquis par M. Max Debbane, d'Alexandrie. Son propriétaire nous a très aimablement permis de le consulter; c'est ainsi que nous avons pu, par recoupements, identifier son auteur.

[3] Cf. notre article *Deux voyageurs suisses dans l'Egypte d'il y a cent ans* (*Revue du Caire,* mars 1957, p. 231-252).

d'accepter et de porter le titre de bey. Epave d'un sanglant naufrage, Em-Bey, tel était son nom, s'était retiré en Egypte après la chute de la république selon son cœur; il ne l'avait plus quittée, et s'y était naturalisé au point d'en adopter les mœurs, jusqu'au harem inclusivement. On disait même, mais c'était une calomnie, que son esclave favorite était sa propre fille. Enseveli dans son désert, il y ruminait ses souvenirs comme le chameau rumine ses aliments, et ne voulait rien savoir de ce qui se passait dans le monde : avec la république tout était mort pour lui. J'avais connu au Caire [1], où il est mort peu de temps après, ce fossile de l'époque révolutionnaire, et retrouvé en lui la personnification fidèle de 1793; il en avait gardé les passions; il en parlait le langage : immuable dans son civisme, il accusait de modérantisme tous ceux qui ne regardaient pas la guillotine comme le meilleur moyen de gouvernement, et sa sensibilité lui faisait une loi de reconnaître l'existence de l'Etre Suprême. C'est de lui que je tiens l'article suivant du catéchisme républicain. On demandait à l'enfant : « Qui es-tu?» A quoi l'enfant devait répondre :

« Homme libre, Français, républicain par choix,
Né pour aimer mon frère et servir ma patrie,
Vivre de mon travail ou de mon industrie,
Abhorrer les tyrans et me soumettre aux lois» [2].

*
* *

Il est difficile de dire à quelle époque les mines d'alun des oasis ont été remises en exploitation. En effet, notre documentation sur la période récente est incomplète parce que les informations écrites sont rares. Tout ce que nous savons, c'est que l'expédition allemande qui parcourut

[1] On se demande pourquoi Jean-Marie Carré (*op. cit.,* t. II, édition de 1932, p. 246; édition de 1956, p. 254) situe la rencontre d'Aymes et de Charles Didier à Assiout.

[2] Charles Didier, *Cinq cents lieues sur le Nil,* p. 358-359. — Ce catéchisme républicain est sans doute celui qui a été publié en août 1793 par Volney sous le titre « Loi naturelle ou catéchisme du citoyen français» (Georges Lefebvre, *La Révolution française* (Peuples et civilisations), p. 577; Louis Villat, *La Révolution et l'Empire, I, Les Assemblées révolutionnaires* (Clio), p. 299).

le désert libyque pendant l'hiver 1873-1874 indique que « Khargeh a fait sur nous l'impression d'un pays en décadence» [1] et que le grand botaniste-égyptologue Schweinfurth, pendant son séjour dans l'oasis de Kharga à la fin du siècle dernier, habitait dans une mine d'alun désaffectée [2]. Mais ces mines retrouvèrent, sans doute pendant la guerre de 1914, leur pleine activité. Ce qui expliquerait les 222 tonnes d'alun qui furent extraites en 1918-1919 [3].

*
* *

En 1874, l'avenir industriel des oasis égyptiennes paraissait bien sombre. « Si l'exploration géologique du désert libyque, écrivait le Dr. Zittel [4], nous a donné des résultats scientifiques importants, il n'en est pas de même pour le point de vue pratique. Il n'y a, d'après mon opinion, aucune espérance de trouver la formation houillère ou des dépôts considérables de combustibles dans le désert libyque qui avoisine l'Egypte. Il n'y a pas de filons métallifères, pas de pierres précieuses. Le sel, le gypse, l'alun se trouvent, il est vrai, en quantités considérables, et le minerai de fer est répandu en masses énormes dans le grès infra-crétacé. Cependant tout cela ne peut pas faire naître une industrie, à défaut de la chose la plus importante, de la houille. La prospérité des oasis est fondée et sera toujours fondée sur leur agriculture, et celle-ci dépend de l'abondance des sources, qu'il est possible heureusement de multiplier presque autant qu'on le veut».

De nos jours la mise en valeur agricole de la Nouvelle Vallée permet tous les espoirs. Rien n'empêche de supposer qu'on peut, dans un temps prochain, y entreprendre une exploitation intensive des ressources du sous-sol, puisque la houille n'est plus considérée comme l'unique force motrice des industries modernes. Certes les progrès de la chimie ont fait découvrir des produits nouveaux qui remplacent l'alun dans son emploi industriel et même médical. Aussi l'exploitation des mines d'alun,

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[1] Rohlfs, dans *Bulletin de l'Institut Egyptien,* 1re série, n° 13, 1875, p. 72.

[2] H.J.L. Beadnell, *An Egyptian Oasis* (Khargeh), p. 21.

[3] A. Lucas, *Ancient Egyptian Materials and Industries,* 3e édition, 1948, p. 292.

[4] Dr Zittel, dans *Bulletin de l'Institut Egyptien,* 1re série, n° 13, 1875, p. 80-81.

plus onéreuse, n'a-t-elle plus qu'un intérêt secondaire. Néanmoins la République Arabe Unie n'a pas encore épuisé ses réserves et peut-être sera-t-il un jour nécessaire de rouvrir les mines des oasis pour un usage imposé par les circonstances ou par une invention nouvelle.

*
* *

En conclusion, résumons les usages de l'alun d'Egypte [1] à la lumière des documents que nous avons analysés :

1. C'est un astringent, fréquemment utilisé en médecine [2].
2. C'est un mordant, employé pour la teinture des étoffes et assurant, notamment sur les cotonnades, la permanence des couleurs [3].
3. Il clarifie les eaux [4].
4. Il sert à la préparation des cuirs [5].
5. Dans les campagnes, les paysans lui attribuent une grande vertu contre le mauvais œil [6] et le réservent à un emploi plus personnel [7].

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[1] Pour l'analyse chimique de l'alun d'Egypte, cf. G. Hogan, *Note on the Deposits of Aluminium Sulphate at Kharga Oasis,* dans *Egyptian Water Supplies, Report and Notes of the Public Health Laboratories,* 1920, p. 11-12.

[2] Surtout pour la préparation des collyres secs (Max Meyerhof, *Un glossaire de matière médicale composé par Maïmonide,* Mémoires de l'Institut d'Egypte, t. XLI, p. 184).

[3] Pline l'Ancien, *Histoire naturelle,* XXXV, 42 et 52 ; Lucas, *op. cit.,* p. 291-293 ; Clot-Bey, *Aperçu général sur l'Egypte,* t. II, p. 273 et 289 ; Moustafa Fahmy, *La révolution de l'industrie en Egypte....,* p. 22-23.

[4] « L'eau du Nil est fort trouble ; on l'épure en la filtrant, ou mieux encore, au moyen de l'alun» (Jean-Jacques Ampère, dans *Revue des Deux Mondes,* t. XIX, 1847, p. 211).

[5] Félix Mengin, *Histoire de l'Egypte.....,* t. II, p. 230 et 422.

[6] Clot-Bey, *op. cit.,* t. II, p. 54. — Nous donnons plus de détails sur ce sujet dans notre article *Gérard de Nerval au Caire* (dans *Revue du Caire,* mars 1956, en particulier p. 180-183) où nous avons comparé, pour expliquer un passage du *Voyage en Orient,* édition Gilbert Rouger, Collection Nationale des Classiques français, t. II, p. 67-68, les informations anciennes de E.W. Lane, *The manners and customs of the modern Egyptians,* édition de 1944, p. 257, et les plus récentes, celles de Miss W.S. Blackman, *Les Fellahs de la Haute-Egypte,* collection Payot, p. 187.

[7] « (Mon père) vendait.... des sels d'alun qui clarifient l'eau sale et qui, lui entendais-je raconter, sont employés par les femmes pour augmenter le plaisir des hommes» (John Knittel, *Le Docteur Ibrahim,* Assiut, chapitre I).

ON A NEW CLASSIFICATION

OF THE

BASEMENT ROCKS OF THE RED SEA HILLS SUDAN

BY

M. LOTFI AND M. L. KABESH

I. INTRODUCTION.

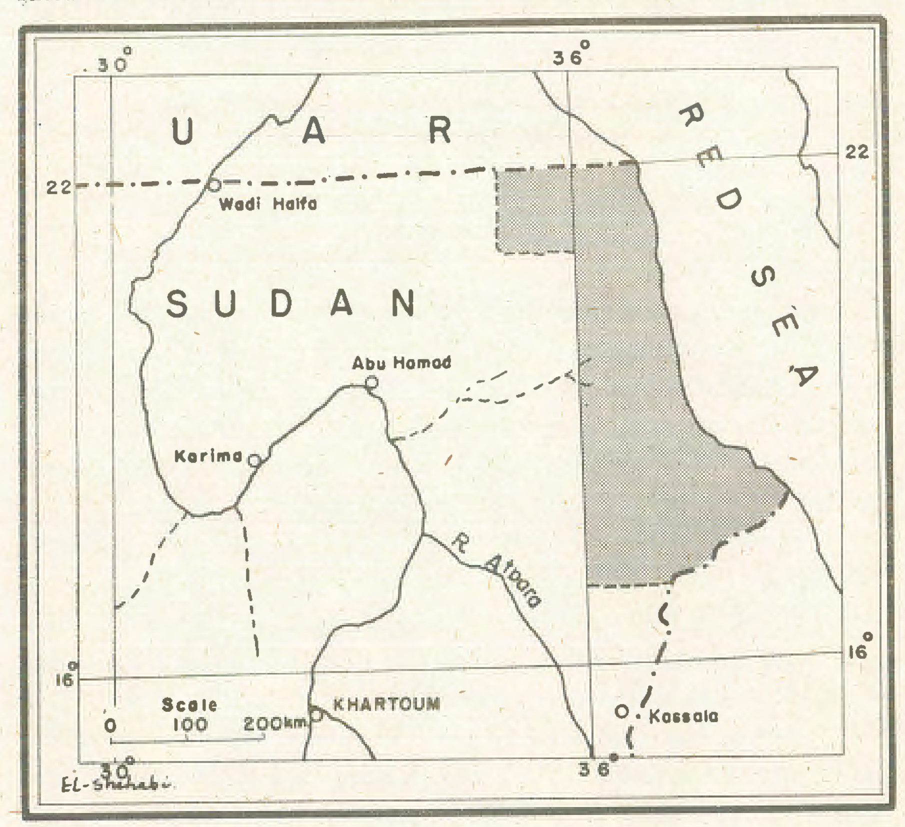
The basement rocks form the major part of the Red Sea Hills of the Sudan, occupying the area between latitudes 17° and 22° N. and longitudes 35° and the Red Sea coast east. The classification of these rocks attracted the attention of several workers of the Geological Survey of the Sudan. They advanced classifications based mainly on regional geological mapping and some petrographic studies.

The present writers mapped separately on a scale of 1:250,000 Muhammad Qol and Port-Sudan Sheets which cover collectively an area of about 25,000 sq. kms. of basement rocks (see key map). Field mapping was undertaken during three consecutive field seasons totalling about 11 months for each map sheet.

The writers also studied some parts in the central sector of Sinkat Sheet lying to the south of the above mentioned areas. Certain conclusions were reached by the present workers concerning the stratigraphic sequence of the different rock formations taking in consideration the previous classifications.

In the present paper a review of the previous classifications is given which comprise Andrew (1948), Gass (1955), Ruxton (1956), Gabert-Ruxton-Venzlaff (1960) and Kabesh (1962), in addition to a new-classification proposed by the present authors and which may be considered as a step foreward towards a better understanding and a unification of the different rock formations.

The nomenclature of the major rock groups adopted in this work intentionally avoids the geographical terms used traditionally by other workers. This may help in any further large-scale grouping of basement rocks in various parts of the Sudan. No attempt has been made to discuss the petrography of the rocks which will form the subject matter of a future work.



II. PREVIOUS CLASSIFICATIONS.

The previous classifications of the basement rocks in the Red Sea Hills are listed in Table 1.

From the table it is clear that the various trends of classification for the basement rocks proposed by these workers agree more or less in their broad outlines which constitute the frame-work of any of these

TABLE 1.

ANDREW (1948)	GASS (1955)	RUXTON (1956)	GABERT-RUXTON-VENZLAFF (1960)	KABESH (1962)
TOP 6. Soda-granites. 5. Unfoliated granites, etc... *B*) Folding of non-metamorphic succession. 4. Unmetamorphosed greywackes and lavas (predominantly andesitic). Folding and regional metamorphism (? A continued). 3. Plutonic intrusions : ultrabasic rocks (sepentines, etc...) gabbro, norite, granodiorite, granite, all more or less foliated. *A*) Folding and regional metamorphism. 2. Oldest plutonic orthogneisses. 1. Regionally metamorphosed para-schists, containing many slightly metamorphosed bedded rocks, including lavas. BASE	TOP Younger Granite : Granite, granophyre, quartz syenite. *Tectonic Phase* Basic Intrusions : Gabbros, Troctolite, Pyroxenite. Batholithic Granite : Biotite-Hornblende Granite. Assimilation Granite : Biotite-Hornblende-Granodiorite. *Tectonic Phase* Oyo Series : Pelites, Quartzites, marbles, conglomerates, acid volcanics. *Tectonic Phase* Granite Gneiss, Metamorphic schists acid volcanics (unless known from the conglomerates of Oyo series). BOTTOM	TOP 9. Major faulting. 8. Acid and basic sills and dykes. 7. Red granite. 6. Injection granite-Large scale metasomatism. 5. Awat Series : (*d*) Massive acid volcanics. (*c*) Silty mudstones and acid volcanics. (*b*) Conglomerates. (*a*) Massive silty mudstones. Uplift and Erosion. 4. Basic Intrusives. Large scale folding. 3. Nafirdeib Series : Limestones, quartzites and pelites. Intermediate volcanics and greywackes. Basic and intermediate volcanics and greywackes. Uplift and Erosion. 1. and 2. Primitive System. 2. Basic dyke swarms. Large scale folding and regional metamorphism. 1. (*d*) Granite pegmatites. (*c*) Acid gneiss. (*b*) Schists and slates. (*a*) Hornblende schist and gneiss. BASE	TOP 8. Younger granites including the injection granite with large scale dioritisation, the red granite, soda-granite and syenites. 7. Awat Series including acid volcanic rocks, silty mudstones and conglomerates. 6. Basic Intrusives including norites, gabbros and serpentines. 5. Large-scale folding and regional metamorphism. 4. Batholithic microcline granite with large-scale dioritisation, microcline and hornblende-gneisses. 3. Nafirdeib Series including intermediate volcanic rocks, pelites, quartzites, marbles and conglomerates. 2. Tectonic disturbance and regional metamorphism (formation of mixed and banded gneisses). 1. Kashebib Series (mixed and banded Paragneisses). BASE	TOP — Alkaline and Basic Volcanic Suite. *Volcanism* Unconformity — Post-Granite Dykes (including alkaline, basic, intermediate and acidic). *Tectonism and Volcanism* — Younger Granites (including microcline granite, white granite, pink-red granite, with granodiorites, monzonites in association). — Grey Granites. *Tectonism and Plutonism* Awat Series : (Massive silty mudstones, microconglomerates, acid and intermediate volcanics). Unconformity — Gabbros and Related Rocks (including troctolites). — Epidiorite-Diorite Association. — Serpentines. *Folding and Faulting* — Nafirdeib Series : (*b*) Meta-andesites, meta-dacites, andesitic tuffs and agglomerates, minor meta-quartzites, marbles and greywackes. (*a*) Chlorite-sericite schists, lowgrade-phyllites, with feldspathic and epidotic hornblende schists, mudstones and greywackes. Unconformity ? — Gneisses (including para- and orthogneisses). BASE

classifications. The following remarks can be concluded from a close comparison of the major rock groups and intervening movements.

1. Folding movement before the younger granites is absent in Gabert-Ruxton-Venzlaff's classification.

2. Awat Series is missing in Gass's classification.

3. Ruxton mentioned only the basic intrusives and did not report on the batholitic granites.

4. Ruxton has divided the older metamorphosed sediments and lavas into two groups, one pre- and one post- the oldest plutonic orthogneisses of Andrew.

5. Oyo Series of Gass corresponds to Nafirdeib Series of Ruxton, Gabert-Ruxton-Venzlaff and Kabesh.

6. Nafirdeib and Awat Series show a heterogenous character and lack uniformity of composition.

III. PROPOSED CLASSIFICATION.

The classification proposed by the present authors is given in the following :

Top : Faulting movement

Dykes
Alkaline granites
Post-geosynclinal intrusives (large scale acid intrusives including granites, syenites, diorites etc.)

Mild orogeny

Third geosynclinal deposition

acid and intermediate volcanics
micro-conglomerates
greywackes and mudstones

Unconformity

Dykes
Post-geosynclinal intrusives (serpentines, gabbros, troctolites)
Orogeny accompanied by large scale emplacement of Batholithic granite

Second geosynclinal deposition

limestones and quartzites
conglomerates
hornblendic rocks
greywackes and slates with volcanic rocks
conglomerates

Unconformity
Orogeny

First geosynclinal deposition

calcareous schists
conglomerates, greywackes and slates with volcanic intercalations

Unconformity?
Orogeny

Para-gneisses and ortho-gneisses

Base :

It is obvious from this proposed classification that we have at least three periods of geosynclinal deposition, each followed by orogenic movements and separated by unconformities.

The oldest rocks so far recorded are represented by various ortho- and para-gneisses covering considerable areas in the northern part of Muhammad Qol and Deraheib Sheets. These rocks are folded into a number of open anticlines and synclines with their axes trending in a N.E.-S.W. direction.

These gneisses are unconformably overlain by the different members of the first geosynclinal sediments represented by a thick succession including greywackes and slates and which may be associated with

volcanic intercalations followed by calcareous sediments. Conglomeratic beds may be present at the base. These components are affected by orogenic movements causing the development of large folds trending in a nearly N.-S. direction. They are well represented in the central and extreme northern parts of Muhammed Qol Sheet. However, local deviations from this regional trend are not uncommon due to later movements.

The unconformity separating these folded sediments from the following geosynclinal phase is well displayed in some localities of the examined areas, as in the extreme northern part of Muhammad Qol Sheet.

The second geosynclinal sedimentation is also represented by a thick pile of sediments and volcanics comprising from base to top the following succession :

conglomerates
greywackes and slates with volcanic rocks mostly andesitic.

hornblendic rocks of basic igneous origin or of calcareous sedimentary origin.

conglomerates
limestones and quartzites.

This was followed by main orogeny accompanied by large scale folding having a N.E.-S.W. trend. These sediments occupy a large part of the area examined both in Muhammad Qol and Port-Sudan Sheets. During this phase there may be interruptions in the deposition shown by thin intercalated conglomeratic beds.

Towards the close of this phase, emplacement of batholithic granites took place on a major scale mostly parallel to the structural axes of the folded sediments. The batholithic granites comprise different varieties of granodiorites, quartz-diorites and monzonites. These are well represented in Port-Sudan and Deraheib Sheets. Types with well defined gneissic structure may be encountered in Sinkat Sheet in the vicinity of Erkowit. Banding in these rocks has a N.E.-S.W. trend following the regional structure of the whole area.

Basic intrusives of serpentines, gabbros, troctolites and diorites are recorded in various parts intruding the batholithic granite and the

metasediments. Outcrops of these basic intrusives are, in most cases, elongated parallel to the structural trend of the area. These rocks are not seen in the field cutting the succeeding formations.

Dykes and sills traverse the previous formations. They possess two main directions, N.-S. and N.N.E.-S.S.W. and comprise acidic, intermediate and basic types. They may occur in parallel swarms, sometimes covering a large proportion of the country.

Then followed the third geosynclinal deposition of sediments formed mainly of an interbedded complex association of massive mudstones, microconglomerates, greywackes and acid and intermediate volcanics (the latter predominating in Port-Sudan Sheet).

This phase is demarkated from the previous formations by an unconformity well represented in the south central part of Muhammad Qol Sheet. Mild orogenic movements are exhibited by the occurrence of different folds trending mostly in a N.E.-S.W. direction.

At the end of this phase a conglomeratic bed, at least 100 mts. in thickness, was recognised thus marking the close of the geosynclinal deposition. This is best shown at Gebel Awat in Muhammad Qol Sheet.

This geosynclinal deposition was followed by large scale intrusions in the whole area comprising granites, syenites, diorites and finally alkaline granites. Granites dominate in the eastern part of Muhammad Qol Sheet forming the back-bone of the sheet. Plutons and bosses of variable dimensions are recorded in the area studied. Syenite is recorded in Port-Sudan Sheet, while the alkaline riebeckite granite forms the outcrop of Gebel Okwar S. W. of Summit in Sinkat Sheet and is also recorded in the extreme N.E. part of Derudeb Sheet.

Younger dykes represented by bostonites, trachytes, aplites, porphyries, porphyrites, lamprophyres and quartz veins invade the previous formations and possess N.-S. and E.-W. trends.

The basement rocks were then affected by faulting movements in various parts by dislocations of younger dykes and by shearing and brecciation of the different formations. These movements may cause local deviations of the regional foliation. Sometimes the drainage pattern is controlled by faulting and shearing. This is exemplified by certain parts along the course of Khors Arbaat and Okwar in Port-Sudan Sheet.

IV. CONCLUSIONS.

Due to lack of absolute age determinations of the different rocks of the Sudan basement complex as no studies have been done so far, the present workers depend mostly in the classification proposed in this survey on the relations in the field. In this classification three geosynclinal phases are recognised separated by orogenies and unconformities. The vast areas studied (about 25,000 sq.kms.) lay a concrete basis for this conclusion and a wider view for possible regional correlations of the various rock formations. Each geosynclinal phase is divided into a stratigraphic sequence which may be applicable to other areas not yet examined in the Red Sea Hills of the Sudan.

ACKNOWLEDGMENT

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THE HIGH DAM LAKE IN ASWAN

A NEW ENVIRONMENT IN THE MAKING

BY

I. RIZKANA AND M. S. ABOU EL EZZ

With the march of time, authorities in Nile control in Egypt eventually realized that Aswan, Jebel Aulia reservoirs and the other Nile control projects, were however, far from complying with the water requirements of the Country. The conception of the High Dam project stems from such a realization accelerated by the pressing need for agricultural and industrial development, to cope with the needs of a rapidly growing population [1].

1. The site chosen for the construction of the Dam lies some six kilometres upstream of Aswan between the latitudes of Khor Agurma in the north and Khor Kundi in the south. At this site, the river bed lies at approximately 100 metres above mean sea level. On either bank, the land rises precipitously to an altitude ranging between 190 and 210 metres above sea level [2].

2. At completion, a massive wall of concrete 110 metres high and 5000 metres in length, will be erected across the Nile. Such a colossal wall will definitely become Africa's greatest mass of masonary, and its storage capacity will exceed 180 milliard cubic metres or more than three times that of the Boulder Dam in the United States. The live storage

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(1) A. A. El Tonbary and M. S. Abou El Ezz, Economics of water supply and control in the Southern Region of the U. A. R. : An outline. *Inter. Journ. Agr. Af.*, vol. III, Oxford Univ. Press, 1961, p. 27.

(2) H. Awad, Le Sadd El-Ali, le plus grand réservoir du monde et ses conséquences géographiques. *Bull. Soc. Géog. d'Egypte,* T. XXX, 1957, pp. 8-10.

of the High Dam however, is 70 milliard cubic metres after allowing for flood protection and silting. This is equivalent of 14 times that of Aswan Dam [1]. The effect of this Dam will be to impound behind it a lake containing a huge mass of water covering an area of more than 4000 kilometres. It is expected that the lake will extend 500 kilometres upstream to the Dall cataract in the Republic of the Sudan. This means that the High Dam lake will extend some 350 kilometres in the southern extremity of Egypt and about 150 kilometres in the Sudan. The width of the lake ranges between 1000 metres (in Kalabsha gorge) and 20,000 metres with an average of 8 kilometres. The level of the lake behind the Dam will attain its maximum at 188 metres above sea level. The exact time it will take to fill the lake to full operating level, however, cannot be calculated accurately, but if the Nile discharge during the flood season is average, the required level will be attained in three years after the completion of the Dam. Nevertheless, intervening years of low or high floods could retard or advance the filling process [2].

3. The high dam lake when filled to capacity will take an elongated shape coinciding with the reach of the Nile extending between just above the city of Aswan and the Dale cataract. Its area will be delimited by the 180 m. contour with projecting arms in the debouches of the various valleys which dissect the two bounding plateaux, though with remarkable frequency in the eastern side. Chief amongst these valleys are (from south to north) : Khor Ambilcol, Wadi Hamid, Wadi Korosko, Wadi Alaqi in the east and Wadi Kalabsha in the left side [3]. Wadi Alaqi stands out without a rival as the largest and longest of all the dry valleys of the eastern desert with the exception of Wadi Qena. The area covered by its drainage basin exceeds 44,000 square kilometres, and its length is over 350 kilometres or equivalent to the length of the Nubia Nile within

(1) El Tonbary A. A. and Abou El Ezz, M. S., *Ibid.*, p. 28.

(2) Selim, M. A., The High Dam project. *Bull. Soc. Géog. d'Egypte*, T. XXVIII, 1955, p. 111-117.

(3) See, *The Topographical Atlas of Egypt*, scale 1 : 25,000 (The new series) and also the 1 : 100,000 series.

the boundaries of Egypt. The average width of its debouch in the flood plain is some six kilometres [1]. The waters of the artificial lake will, therefore, penetrate towards the east more than 10 kilometres before attaining the level of 180 metres a.s.l. The newly-formed lake will thus have a rather unique shape with arms and gulfs which are hemmed in between the high scarps and interfluves of Nubian Sandstone.

4. This sector of the Nile valley is affected by faulting. The movements are not ancient, and possibly dating as far back as the tertiary [2]. There is a conjecture therefore as to what effects may be caused by the loading of the earth's crust in southernmost Egypt with the weight of the enormous volume of water contained in the High Dam lake. Geologists are cognizant of the fact that the weight of water in the Boulder Dam lake caused a « bend » in the earth's crust [3]. As to whether or not such an after-effect is likely to occur in Nubia, is rather speculative and could not be accurately gauged without thorough studies and special levelling.

5. The possibility of the lake creating a microclimate is controversial. In this connection, however, one can only assume that owing to its elongated shape and relatively small area, the dominant prevailing north-westerly winds will only have an insignificant water « fetch» and consequently will not cause any marked microclimatic alterations. Apart from some local land and water breezes that might affect the lake shores, the creation of the lake will not lead to any change in local climate [4].

6. As has been stated above, the Nubian Nile is hemmed in between high plateaux on either side towering more than 210 metres above the flood plain of the river. The flood plain itself is nothing more than a series of cultivated patches entirely isolated and surrounded by high

(1) Ball, J., The Geography and Geology of South Eastern Egypt. Cairo, Govern. Press, 1912, pp. 78-93.

(2) Yallouze, M. and Knetsch, G., Linear structures in and around the Nile Basin. *Bull. Soc. Géog. d'Egypte*, T. XXVII, p. 174-175.

(3) Reeve, W. H., Progress and Geographical significance of the Kariba Dam. *Geog. Journ.*, vol. CXXVI (Part 2), 1960, p. 146.

(4) *Ibid.*, p. 145-146.

cliffs. That part of the floor of the Nile had been for large number of generations, occupied by the Konouz in the north, the Arabs in the middle and the Nubians in the south. All three groups have tended to remain isolated and retained a huge assemblage of their ethnic and cultural characteristics. Owing to the flooding of their former lands after the construction of Aswan Dam (1903) and its two heightenings (1912 and 1934) they were moved to safer ground fringing the upper limit of inundation[1]. One of the first outstanding social consequences of the High Dam will be the removal of the 48,000 inhabitants living above Aswan, and whose land will be flooded as the early stages of the Dam are completed. Kom Ombo plain has been chosen as a new home for the Aswan lake dwellers and the process of relocation is now closing its final objective.

7. Since the high dam lake will engulf and submerge the cultural landscape of Nubia, it will therefore, differ radically from the Aswan Dam lake in being almost completely deserted. This will form—in point of fact—a serious obstacle against any future economic development of the lake region. The exploitation of the lake and the lands fringing its shores will no doubt need a community of lake-shore dwellers; a fact which might point to a probable immigration to Nubia in the near future.

8. The different stages of the physiographic history of the Nile in Nubia, are vividly illustrated through a succession of terraces ranging in altitude between 90 and 9 metres above the flood plain. The three uppermost terraces of 90 m., 60 m. and 45 m. date back to the plio-pleistocene, whilst the middle group of 30 m. and 15 m. is lower palaeolithic and the lowermost terrace of 9 m. is lower mousterian (or presumably middle palaeolithic)[2]. The cross section of almost all the dry

[1] Abou El Ezz, M. S., The Norther Part of Aswan Province : Upper Egypt. Unpublished Ph. D. Thesis submitted to Durham University 1953, p. 81-86.

[2] See : *a*) Awad H., *op. cit.*, p. 10.
b) Sandford, K. S. and Arkell, W. J., Paleolithic man and the Nile in Nubia and Upper Egypt. Chicago, 1933, p. 18-24.

valleys—which terminate in the flood-plain either from the east or west—are also marked with a similar succession of river terraces, the most important of which are found at the debouch of Wadi Alaqi. The middle group of terraces (e.g. 30 m. and 15 m.) are composed of Sabilian silt, and are related to an upper-palaeolithic phase of aggradation which choked the debouches of all the dry valleys at their confluences with the Nile[1]. These deposits attain a level of 30 m. above the flood plain in Wadi Halfa, 17 m. at Aswan, 6 m. at Luxor and finally decline to the present level of the flood plain at Nagâ Hammadi[2]. At the time when aggradation was dominant in Nubia, the remainder the Nile course in Upper and Middle Egypt was subject to degradation. But later on, as the volume of water increased (particularly after the advent of the seasonal waters of the floods) Nubia became a region of pronounced erosion which culminated in a series of rapids and cataracts above both Aswan and Wadi Halfa[3]. More recently, however, aggradation was again followed due to the formation of the artificial lake reservoir of Aswan Dam. Hence the first or Aswan cataract of the Nile became a region of deposition and throughout a stretch of more than 340 km. above Aswan Dam the Nile was transformed to a navigable lake whose bottom was gradually silting up[4]. The southward prolongation of the lake for another 160 kms. after the construction of the High Dam will eventually submerge the Second cataract as well and obliterate it completely. Its jutting granitic islands will disappear beneath thick layers of bottom load.

9. The stretch of the Nile course in Nubia prior to the construction of Aswan Dam was by no means in a graded condition. Its longitudinal profile was marked by cataracts and rapids with their characteristic sharp gradients; and hence it had been a typical « interrupted profile »[5]. Its sharp inflections or nickpoints (in Aswan and Semna cataracts) reflect

[1] Huzayyin, S. A., The place of Egypt in Pre-history. Cairo, 1941, p. 152-153.

[2] Ball, J., Contributions to the Geography of Egypt. Cairo, Govern. Press, 1939, p. 68-69.

[3] Huzayyin, S. A., *op. cit.*, p. 151.

[4] Awad, H., *op. cit.*, p. 10.

[5] Thornbury, W. D., Principles of Geomorphology. New York, pp. 109-110.

the local influence of lithology. The cataracts were formed precisely in localities with resistant bedrock of crystalline Pre-Cambrian formations [1]. The construction of Aswan Dam, and the ensuing formation of its lake reservoir; produced an artificial baselevel. The section of the Nile above the Dam (up to 340 kms. to the south) attained a graded condition while exactly below the Dam the Nile remained ungraded and its turbulent waters went on gnawing away and potholing the granites of the first cataract.

10. The High Dam lake no doubt will inundate and obliterate the physical landscape of Nubia; with its river terraces and the nickpoint lying some seventy kms. upstream of Wadi Halfa at Semna. Throughout the whole length of the lake aggradation will supervene, and a new internal Delta will start to form. The gradual formation of the « Nubian Delta» is due to the fact that the High Dam has no sluice gates for the discharge of flood waters. The future internal delta, however, will not become a technological menance to the live capacity of the Dam until after five centuries.

11. Since the process of silting-up of the reservoir will proceed year by year, the stored water reaching Egypt proper downstream of the lake will be devoid of suspended materials. This will also lead to a downvalley decrease in load relative to discharge with consequent increase in the erosive power of the water. Such changes will decrease slope requirements in the downvalley direction, thus preventing the Nile from attaining a slope of transportation or—in other words—a graded profile [2]. The future hydrological policy should, therefore, guard against downstream channel erosion, through rational procedures for protection and shoring up of the river banks.

Thus, the High Dam lake will in the future form a man-made physical landscape whereas, Nubia will become a « fossil » geographical environment.

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(1) Yallouze, M. and Knetsch, G., *op. cit.,* p. 168.
(2) El-Tonbary and Abou El-Ezz, *op. cit.,* pp. 28-29.

12. The lake level, however, will be subject to seasonal fluctuations ranging between 183 m. and 150 m., the latter figure—of course—represents its constant level. Such oscillation will as time goes by cause the deposition of residual silts on the bounding slopes of the lake. Hence, an area of over one million acres in Lower Nubia [1] will become tillable, and suitable for annuals and tropical trees. The levels suitable for practising agriculture could be distinguished as follows :

(*a*) At levels ranging between 200-183 metres above sea level, a considerable area could be devoted to tropical trees, and irrigated by lift during the high-level season of the lake. Such area is beyond the reach of inundation either annually or seasonally.

(*b*) The lands lying between the 170 and 183 metres contours could also be confined to the cultivation of tropical trees. Although, submergence will effect these lands, yet the period of inundation will not exceed three months.

(*c*) At altitudes between 160 and 170 metres which are subject to a six-month season of inundation, annuals could be successfully grown.

(*d*) All the lands lying between the 150 and 160 metres contours-where submergence will last for nine months—; early vegetables that need a short growing season could be raised.

As regards the distribution of arable areas along the shores of the High Dam lake, the following is a tentative portrayal :

(1) Wadi Kurkur on the left bank of the Nile : which is the closest dry valley to the masonary wall of the Dam. Here a considerable area of its lower reach could be exploited.

(2) Wadi Kalabsha on the west side of the lake [2].

(3) Wadi Alaqi and its main tributaries (e.i. Wadi Abosko).

(4) Wadi Tushka in the south.

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(1) Shata, A., The Lower Nuba area, Egypt, U. A. R. *Bull. Soc. Géog. d'Egypte,* T. XXXV, 1962, pp. 274-275.
(2) Wadi Kalabsha is approximately 100 kilometres in length, whilst Wadi Kurkur is only some 50 kilometres.

The waters of the lake will penetrate to considerable distances into the above mentioned valleys, some of which may be converted to subsidiary reservoirs as for instance Wadi Tushka which will change to an isolated lake whose waters could be utilized for the irrigation of all the lands lying above the 180 metres contour.

13. In addition, the presence of a lake of relatively still water in which fish supplies could increase steadily; should also claim interest, and invite further studies. Pesiculture could be carried out through putting fingerlings in the various basins of the lake.

14. The extension of the navigable lake between Egypt and the Sudan will provide an effective link of cheap transportation which will no doubt encourage trade between the two neighbours, particularly when it is known that a considerable percentage of the north-bound traffic comes in merchandises with large volume (e.g. cattle). Interest therefore should be directed to the development of water transport, through the construction of harbours at least at the lake's northern and southern tips. Such harbours could be developed as centres for commercial fishings, lake transport and tourism. The latter activity will no doubt be developed after moving the archaeological sites of Nubia to safer levels beyond the reach of inundation.

15. The comparative remotness of this vast expanse of water to towns such as Aswan and Wadi Halfa will be a havoc to the full utilization of the region without a tremendous expenditure of capital. Coupled to that the resettlement of lake shores is definitely an essential prerequisite to their proper utilization.

To sum up; the pursuance of a policy aiming at the utilization of the High Dam lake-region, will culminate in a number of economic benefits such as :

(1) The exploitation of over a million feddans of cultivable lands.

(2) The resettlement of approximately 500,000 inhabitants through encouraging migration from the congested Qena Province lying to the north of Aswan.

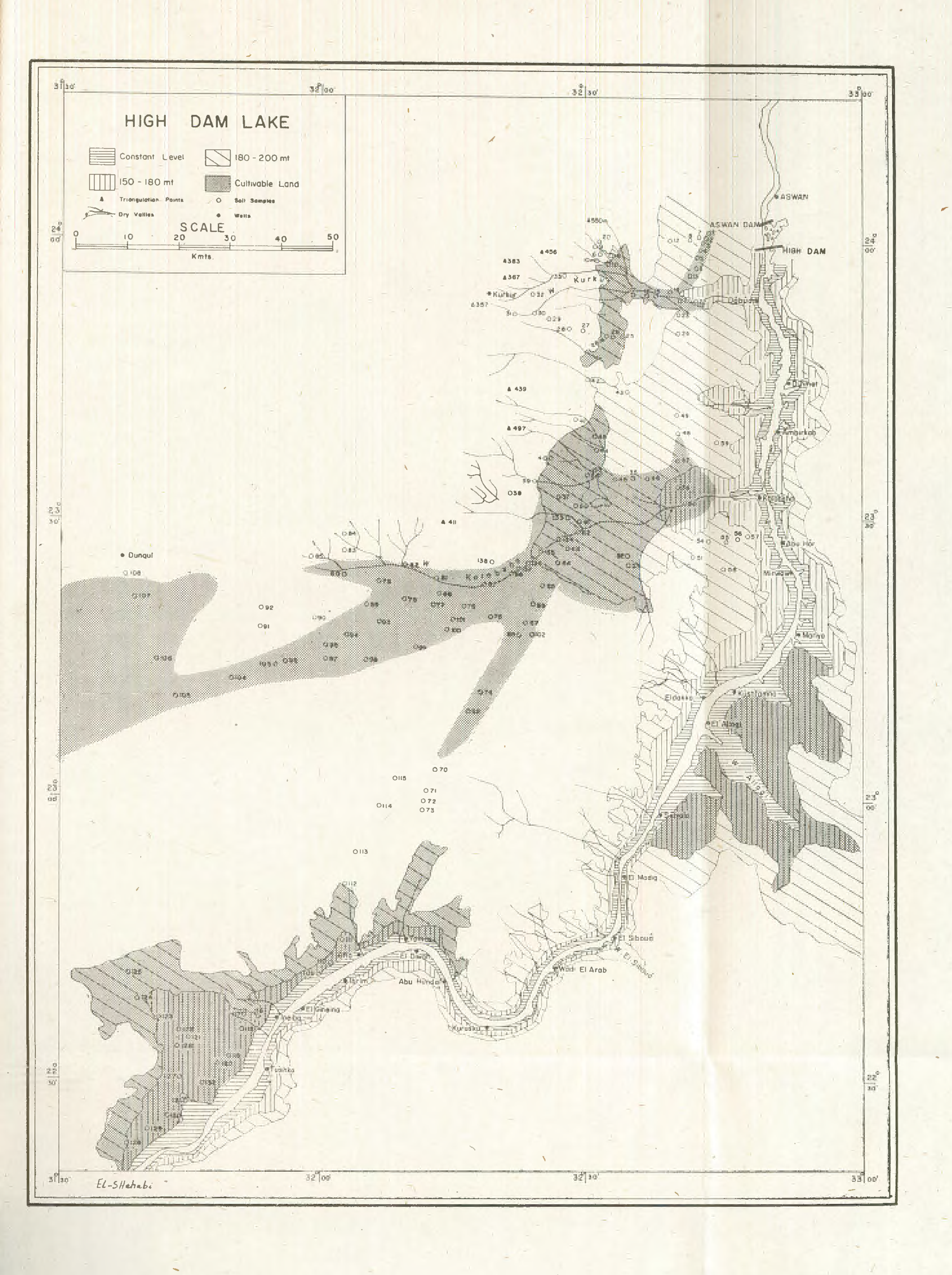
(3) The augmentation of the local production of oils and greases through the cultivation of palm oil, which is experimentally feasible with a high content of oil (68%).

(4) Increasing the total output of fish production, and ameliorating the dietary conditions of the masses.

(5) Enhancing navigation and trade between Egypt and the Sudan.

(6) Increasing the national income through the revenue from tourism.

The region of the High Dam lake thus forms a newly created environment, entirely manmade, and with great potentialities. This no doubt calls for geographers to contribute actively to the development of the new region. Their role should not by any conceivable way be overlooked or undermined.



HIGH DAM LAKE
Constant Level
180 - 200 mt
150 - 180 mt
Cultivable Land
Triangulation Points
Soil Samples
Dry Vallies
Wells
SCALE
0 10 20 30 40 50
Kmts.
31° 30'
32° 00'
32° 30'
33° 00'
24° 00'
23° 30'
23° 00'
22° 30'
ASWAN
ASWAN DAM
HIGH DAM
Dunqul
El Madiq
El Siboua
Wadi El Arab
Abu Hunda
El-Shehabi

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القاهرة

مطبعة المعهد العلمي الفرنسي للآثار الشرقية

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مجلة
الجمعية الجغرافية المصرية

المجلد السابع والثلاثون

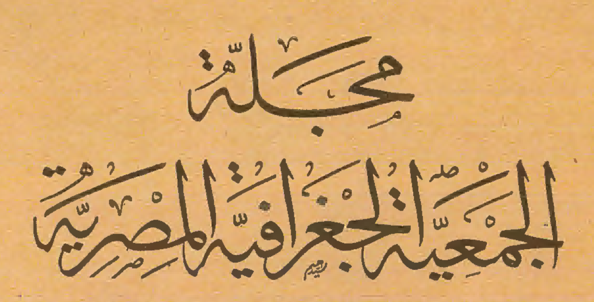
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مجلة الجمعية الجغرافية المصرية

الجمعية الجغرافية المصرية

شارع القصر العينى – مكتب بريد قصر الدوبارة

تليفون ٢٥٤٥٠٠



المجلد السابع والثلاثون

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